TOWN OF KENDUSKEAG FLOODPLAIN MANAGEMENT STUDY

PENOBSCOT COUNTY, MAINE

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In Cooperation With:
Town of Kenduskeag
Penobscot County Soil and Water Conservation District
Maine State Planning Office,
Floodplain Management Program

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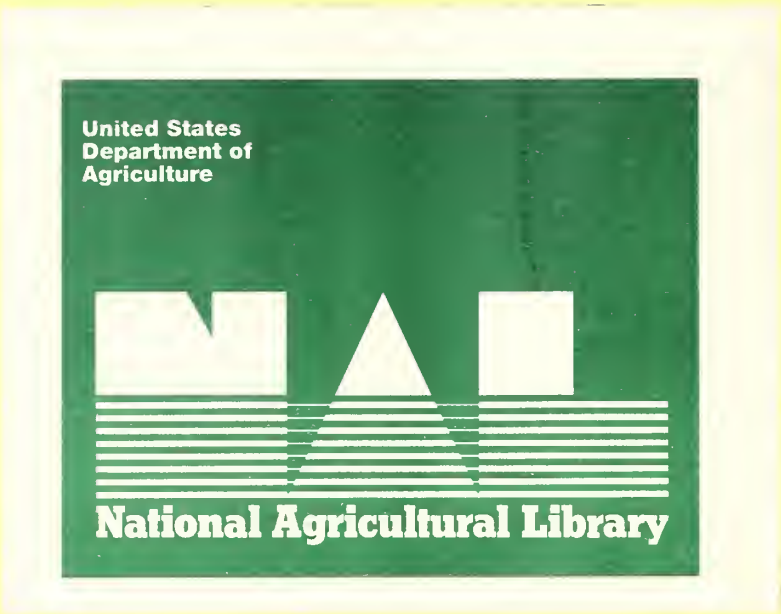

ACKNOWLEDGMENTS

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- Federal Emergency Management Agency (FEMA), Boston, MA
- Penobscot County Soil and Water Conservation District (PCSWCD), Bangor, ME
- Maine Department of Transportation (MDOT), Augusta, ME
- Maine State Planning Office, Floodplain Management Program, Augusta, ME
- National Oceanic and Atmospheric Administration (NOAA), National Weather Service (NWS), Asheville, NC
- Town of Kenduskeag, ME
- United States Army Corps of Engineers (USACE), Concord, MA
- United States Geological Survey (USGS), Augusta, ME

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TOWN OF KENDUSKEAG
FLOODPLAIN MANAGEMENT STUDY
PENOBSCOT COUNTY, MAINE

INTRODUCTION

This Floodplain Management Study (FPMS) report presents floodplain information for the Kenduskeag Stream, and portions of Piper Brook and Partridge Brook within the Town of Kenduskeag, Maine. Data generated consists of a flood hazard evaluation, including floodplain maps and flood profiles, and options for floodplain management.

Technical information and recommendations provided in this report will be useful to the Town in development of its comprehensive plan, identifying floodplain areas, as a guide for developing or improving a floodplain management program for the areas studied, and to update the Town's codes and zoning ordinances. The data generated from this study also will be useful to local, state, and Federal agencies, planning groups, engineers, consultants, and others involved in community planning and the design of hydraulic structures, channels, roads, bridges, culverts, and other community facilities.

This report will facilitate more effective and consistent administration of the community's floodplain management ordinance. Such regulations are needed to minimize loss of life and property damage from future floods, prevent degradation of the watershed's environmental resources, and ensure orderly community growth in areas suitable for development. The report also provides information needed to comply with Maine's 'Mandatory Zoning and Subdivision Control Law', which applies to shoreland areas.

NRCS conducted this study in response to a request by the Town of Kenduskeag to the Penobscot County Soil and Water Conservation District (PCSWCD). The Town submitted a formal application for Federal assistance in developing an FPMS to the Maine State Planning Office, Floodplain Management Program, which establishes study priorities throughout Maine.

NRCS carries out these studies under provisions of Section 6 of Public Law 83-566, the Watershed Protection and Flood Prevention Act of 1954, as amended. Participants cooperated in developing a Plan of Work (POW) dated April 1997.

STUDY AREA

The Town of Kenduskeag is a small, rural community located along Kenduskeag Stream in central Maine. It is situated 12 miles northwest of the City of Bangor, Maine's third largest city (see **Figure 1**). Maine Route 15, a major link between Bangor and points north, bisects the Town of Kenduskeag. The 1990 U.S. Census indicates the town has a resident population of 1,234.

The total land area of the town is approximately 18.5 square miles. Land use is 80 percent forestland, 15 percent is open land including agriculture, and 5 percent is urban and residential.

NRCS has completed soil mapping of the entire Town of Kenduskeag. A soil survey report has been published. Interested individuals may obtain soils information by visiting, writing, or calling the following NRCS field office:

USDA -- Natural Resources Conservation Service
28 Gilman Plaza, Suite #2
Bangor, Maine 04401
Telephone (207) 947-6622.

The Kenduskeag area receives a mean annual precipitation of 41 inches, which includes the water equivalent of 79 inches of snow. The precipitation is distributed evenly throughout the year; however, snowmelt accounts for a large part of the runoff. The mean annual temperature is approximately 43.8 degrees Fahrenheit (^{o}F). Monthly mean temperatures range from a low of 17.5^{o}F in January to a high of 68.2^{o}F in July.

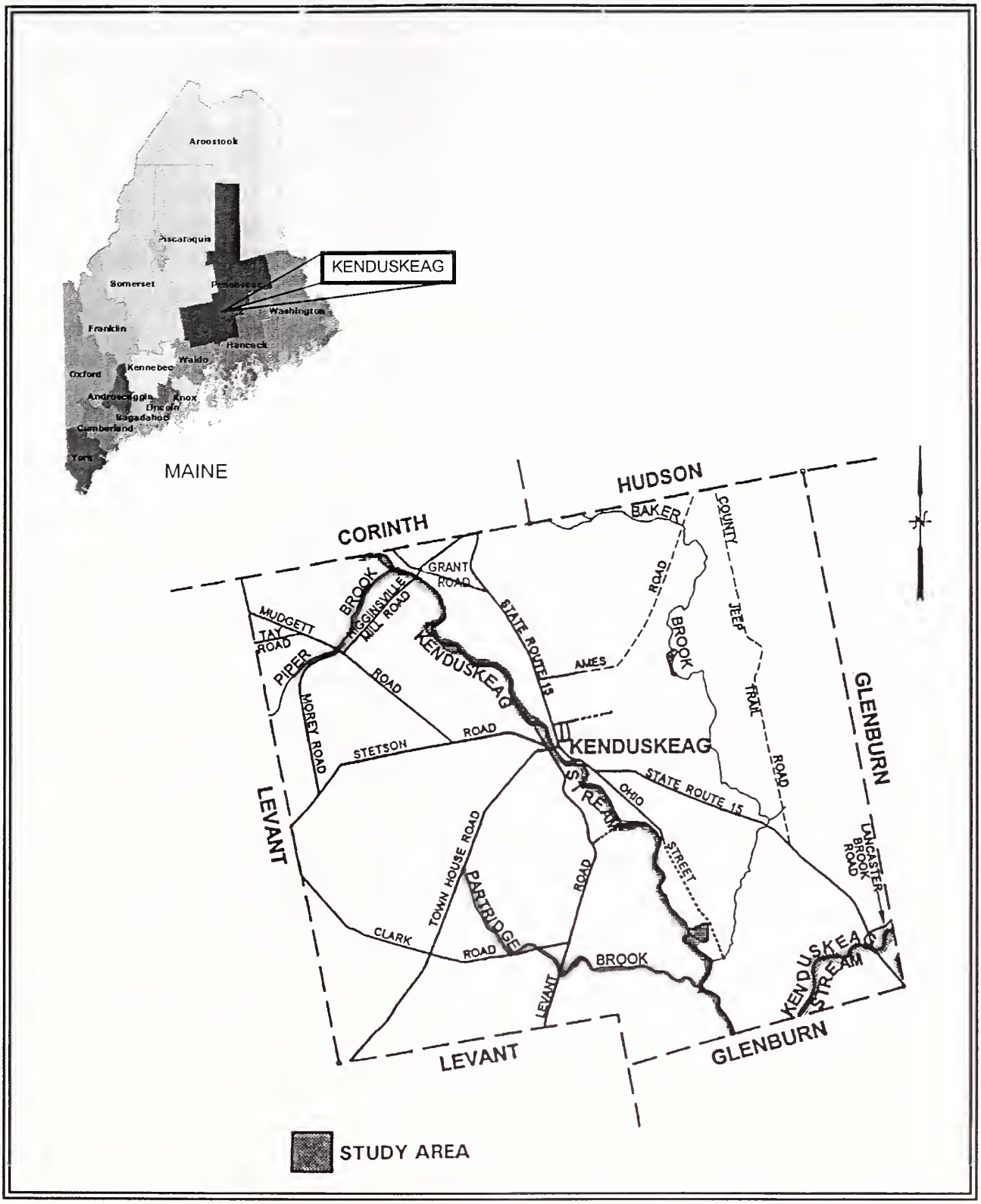

Figure 1 -- Location and Study Area Map
Kenduskeag, Maine

Kenduskeag is located entirely within the Kenduskeag Stream watershed, which is a major sub-basin of the Penobscot River. The NRCS Hydrologic Unit Code for the study area is 01020005180. **(USDA-SCS, 1982)**.

The town's topography consists mostly of rolling hills with bogs and fairly broad floodplains in the valleys along Black Stream, Kenduskeag Stream, and Baker Brook. Elevation extremes are 370 feet near Town House Road at the Kenduskeag - Levant town line, to about 95 feet where Kenduskeag Stream crosses the Kenduskeag - Glenburn town line.

Kenduskeag's economy is closely tied to retailing and manufacturing activities in the greater Bangor area, recreation, and the forest products industry.

Development is heaviest in and around the village of Kenduskeag and along State Route 15. Development within the floodplains studied consists of single family homes, farmland, a golf course, a park, roads, and bridges. The demand for land suitable for development has increased in recent years, resulting in additional pressures to develop floodplain property.

NRCS studied the following streams in Kenduskeag: Kenduskeag Stream for its entire length within the community; Piper Brook, from its confluence with Kenduskeag Stream to a point approximately 1.1 miles upstream; and Partridge Brook from its confluence with Kenduskeag Stream to Town House Road, approximately 3.0 miles upstream.

Kenduskeag Stream, a major tributary flowing southeasterly to the Penobscot River, has a length of 34.2 miles and a drainage area of 215 square miles at its confluence with the Penobscot River in Bangor.

Piper Brook, a tributary flowing northeasterly to Kenduskeag Stream, has a length of 6.0 miles and a drainage area of 7.8 square miles at its confluence with Kenduskeag Stream, near the Corinth town line in northern Kenduskeag.

Partridge Brook, a tributary flowing easterly to Kenduskeag Stream, has a length of 5.9 miles and a drainage area of 2.7 square miles at its confluence with Kenduskeag Stream, approximately 0.5 miles upstream of the Glenburn town line in south central Kenduskeag.

There are eight bridges and culverts on the streams studied in Kenduskeag. These include three on Kenduskeag Stream, one on Piper Brook, and four on Partridge Brook (see **Bridge and Culvert Data**, Page 11, for further information).

Historically, there have been several dams located on the streams studied in Kenduskeag. Only remnants of these dams remain.

Natural Values

Today's uses of the streams in Kenduskeag are primarily recreational and include such activities as: fishing, canoeing, swimming, and snowmobiling.

Other popular activities in the area are small and big game hunting, golfing, cross-country skiing, bicycling, picnicking, hiking, fall foliage touring, camping, photography, and nature study. The watersheds of the streams studied support a wide variety of wildlife, birds, and fish, and provide a source of water for homes, farms, and fire protection.

Flood Problems

Kenduskeag's flood history indicates that damages can occur at any time during the year, but particularly in the winter and early spring months following heavy rainfall on snow-covered or frozen ground; in summer following intense thunderstorms; and in summer and fall during tropical hurricanes. Ice jams on Kenduskeag Stream near Kenduskeag Village often compound flood problems (see photos on page 6 of 1970 flood).

The most recent serious flooding in Kenduskeag occurred in April 1987 and had an estimated frequency of approximately 50 years. Damage caused by that flood and others has been to single family residences, farmland, roads, and bridges. Stream bank erosion is also a problem during flood events.

Tables 1 and 2 summarize the approximate extent of flooding caused by the 100-, and 500-year events to structures and floodplain land.

Kenduskeag Stream
at
Kenduskeag Village

Ice Jam Flood – February 1970

Table 1 -- APPROXIMATE NUMBER OF STRUCTURES IN THE FLOODPLAINS STUDIED

STRUCTURE TYPE	100-YR.	500-YR.
RESIDENTIAL	26	26
OTHER	2	2
TOTAL	28	28

Table 2 -- APPROXIMATE FLOODPLAIN AREAS (ACRES) [1]

LOCATION / LAND USE	100-YR.	500-YR.
KENDUSKEAG STREAM		
Openland	52	59
Forest	133	150
Wetlands	240	254
Urban	14	17
PIPER BROOK		
Openland		1
Forest	12	13
Wetlands	15	19
PARTRIDGE BROOK		
Openland	15	17
Forest	78	101
Wetlands	5	5
Urban	1	1
TOTAL	565	637

[1] *Classified by apparent primary land use. Does not include normal stream or pond area. Urban areas include commercial, municipal, residential, and recreational properties, and roads and bridges.*

ENGINEERING METHODS

For the flooding sources studied in Kenduskeag, NRCS used standard hydrologic and hydraulic study methods to determine the elevation and areal extent of floods. Flood events of a magnitude that are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) were selected as having special significance for floodplain management in the town. The common terms for these floods are the 10-, 50-, 100-, and 500-year frequency floods. Although this frequency designation does represent the long term average time between floods of a specific magnitude, floods do not occur at regular, predictable intervals. The more correct terms for these floods are the 10-, 2-, 1-, and 0.2-percent chance flood events, but this report generally will use the long-established and widely recognized 'frequency' designation.

Rare floods could occur at short intervals or even within the same year. When one considers periods greater than 1 year, the risk or probability of experiencing a rare flood increases. For example, the probability of having a flood that equals or exceeds the 1-percent chance (100-year) in any 50-year period is approximately 40 percent (4 in 10), and for any 90-year period, the risk increases to approximately 60 percent (6 in 10.) The analyses reported herein reflect flooding potentials existing at the completion of field surveys for the study.

Hydrologic Analyses

NRCS conducted detailed hydrologic analyses to establish the peak discharge-frequency relationships for each flooding source affecting the community.

Flood discharges for Kenduskeag Stream were computed using a log Pearson Type III analysis of the former USGS stream gage (No. 01036500) located just above State Route 15 in Kenduskeag.

NRCS used the Technical Release Number 20 (TR-20) hydrologic evaluation model **(USDA, SCS, 1983)** to compute discharges on Piper Brook, and Partridge Brook. TR-20 is the designation for a watershed

computer model entitled Computer Program for Project Formulation - Hydrology. The program is a physically based event model that computes direct runoff resulting from any synthetic or natural rainstorm. It takes into account conditions having a bearing on runoff, develops a hydrograph, and routes the flow through stream channels, reservoirs, and natural storage areas. It combines routed hydrographs with those from other tributaries. The program includes provisions for hydrograph separation by branching or diversion of flow and the addition of baseflow. There is no provision for recovery of initial abstraction or infiltration during periods of no rainfall during an event. TR-20 does not have a groundwater component.

The program can compute peak discharges, their times of occurrence, volumes of runoff, water surface elevations, and duration of flows at any desired cross section or structure. It conducts detailed hydrologic analyses to establish the peak discharge-frequency relationships for each flooding source studied.

Routine manual or computer-aided computations for subwatershed times of concentration and flood routing reach lengths were made with the aid of 7.5' topographic maps. NRCS developed composite runoff curve numbers based on existing land use.

The TR-20 model used historical rainfall data for all evaluated frequencies. Modeled storms had a 24-hour duration and an NRCS Type I rainfall distribution.

Table 3, **Summary of Discharges**, shows a summary of the relationships of drainage area to peak discharge for each stream studied in Kenduskeag.

Table 3 -- SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA ($MI.^2$)	PEAK DISCHARGES (CFS) 10-YR.	50-YR.	100-YR.	500-YR.
KENDUSKEAG STREAM					
State Route 15	176.0	5,470	7,150	7,830	9,370
Stetson Road	116.3	3,930	5,130	5,620	6,730
Higginsville Road	113.9	3,860	5,040	5,030	6,610
PIPER BROOK					
Mudgett Road	7.6	900	1,520	1,790	2,430
PARTRIDGE BROOK					
Levant Road	1.9	305	530	630	865
Clark Road	1.7	285	490	585	800
Private Drive	1.5	270	460	545	745
Town House Road	1.1	230	390	460	620

Hydraulic Analyses and Floodplain Delineation

Detailed hydraulic studies were conducted to provide estimates of the elevations of floods of the selected recurrence intervals on each stream studied in Kenduskeag. NRCS's Water Surface Profile 2 (WSP2) computer program **(USDA, SCS, 1993)** provided information on elevation, discharge, flow area, and flooded area at specified locations along stream valleys. The program can compute up to 15 water surface profiles in one pass through the watershed. It uses the standard step method, with some modifications, to compute profiles between valley cross-sections. At a road crossing, it calculates head loss through a bridge opening, culverts, or a combination of them. It can compute flow profiles for subcritical and critical flow. The TR-20 program uses valley cross-section hydraulic ratings and structure ratings generated by WSP2 to reach-route flood hydrographs through valley reaches and reservoir route through storage areas.

NRCS conducted field surveys to obtain cross-section data for all streams studied in Kenduskeag. All bridges, and culverts were surveyed to obtain elevation data and structural geometry (Table 4, **Bridge and Culvert Data**, page 11).

The **Flood Profiles** and **Flood Hazard Area Maps** show the locations of selected cross sections used in the hydraulic analyses.

The hydraulic analyses for this study assumed that flow was unobstructed. The flood elevations shown on the profiles are thus valid only if hydraulic structures remain unobstructed, and do not fail. Historic ice jam data was used to compute the 100-year flood level in the vicinity of Kenduskeag Village.

The reference for all elevations is the National Geodetic Vertical Datum of 1929 (NGVD). **Flood Hazard Area Maps** show the locations of elevation reference marks used in this study. Table 5, **Elevation Reference Marks**, on pages 12 and 13 contains reference mark descriptions.

The boundaries of the 100-, and 500-year floods shown on the **Flood Hazard Area Maps** were delineated from elevations determined at each cross section. Between cross sections the boundaries were interpolated using topographic maps at a scale of 1:24,000 and contour interval of 10 feet. Field survey information, engineering computations, and other data pertinent to the study are on file and available for review at the following location:

USDA -- Natural Resources Conservation Service
967 Illinois Avenue, Suite #3
Bangor, Maine 04401
Telephone (207) 990-9100.

Table 4- BRIDGE AND CULVERT DATA [1]

LOCATION	CHANNEL BOTTOM ELEV.	LOW CHORD ELEV.	ROAD OVERFLOW ELEV.	FLOOD ELEVATIONS 10-YR.	50-YR.	100-YR.	500-YR.
KENDUSKEAG STREAM							
State Route 15	91.2	112.5	115.3	105.1	106.5	107.7	109.1
Stetson Road	109.4	122.3	124.3	119.6	120.4	121.6/123.5[2]	122.7
Higginsville Road	121.2	135.6	137.7	130.4	131.2	132.0	133.0
PIPER BROOK							
Mudgett Road	185.2	197.7	200.4	194.6	197.4	198.4	198.4
PARTRIDGE BROOK							
Levant Road	152.8	156.8	158.0	158.7	158.9	159.0	159.2
Clark Road	171.1	175.1	178.1	178.6	178.9	179.0	179.2
Private Drive	175.5	176.3	178.7	179.9	180.4	180.6	181.1
Town House Road	224.3	227.3	229.9	230.4	230.6	230.7	230.9

1 Elevations in feet NGVD, at upstream end of bridge or culvert opening.
2 100-Year flood elevations without/with ice jam at Kenduskeag Village.

Table 5 - ELEVATION REFERENCE MARKS (RM)

RM #	ELEV. [1]	DESCRIPTION OF LOCATION
RM 1	120.156	USGS standard tablet, stamped "TT21 WCE 1942, RESET 1971", at the State Route 15 bridge over the Kenduskeag Stream, set on top of the concrete abutment at the northwest end of the upstream guard rail.
RM 2	117.86	Horizontal nail in steel disk, set in the base of unmarked utility pole, 0.7 miles southeast along Old Ohio Street from its intersection with State Route 15, pole nearest gate at the end of pavement, in the northeast face of the pole, 19 feet southwest of the centerline of Ohio Street and approximately 1 foot above ground level.
RM 3	126.700	USGS standard tablet, stamped "CH 3 1942", at the Stetson Road bridge over the Kenduskeag Stream, set on top of the north end of the east concrete abutment.
RM 4	139.82	Chiseled square, painted orange, on top of the northeast concrete wingwall of the Higginsville Road bridge over the Kenduskeag Stream.
RM 5	137.20	Stamped "001", painted orange, 0.2 miles northwest along Robyville Road from its intersection with Higginsville Road, on top of the upstream end of a 3.5' diameter CMP culvert at the Grant Road crossing of small stream, 250' southeast of the Kenduskeag/Corinth town line.
RM 6	201.24	Chiseled square, painted orange, on top of the southeast end of the downstream concrete headwall of the Mudgett Road bridge over Piper Brook.

[1] *National Geodetic Vertical Datum of 1929.*

Table 5 - ELEVATION REFERENCE MARKS (RM)		
RM #	ELEV. [1]	DESCRIPTION OF LOCATION
RM 7	156.72	Stamped "003", painted orange, on top of the upstream end of a 4' diameter CMP culvert at the Levant Road crossing of Partridge Brook.
RM 8	175.11	Stamped "004", painted orange, on top of the downstream end of a 4' diameter CMP culvert at the Clarke Road crossing of Partridge Brook.
RM 9	227.35	Stamped "001", painted orange, on top of the upstream end of a 3' diameter CMP culvert at the Town House Road crossing of Partridge Brook.

[1] *National Geodetic Vertical Datum of 1929.*

FLOODPLAIN MANAGEMENT

The topography of a watershed dictates to a large extent what flood problems might occur. Natural drainageways on the hills form numerous tributaries to streams studied. The steepness of their watersheds produces very quick and flashy flood peaks.

Natural channels draining the uplands erode and become deeper due to steep channel gradients and high velocities. Flatter gradients and lower velocities in the valleys deposit the eroded material in sand bars in the channel. As a result of the erosion and deposition process, and debris and ice jams, valley channels tend to fill in and become wider.

Historically, transportation systems tend to follow streams and rivers because of ease of access and construction. Towns develop along streams at sites where industry built dams for water power. The transportation system and towns are subject to flood damage when they lie

within the floodplain. Development in outlying areas usually occurs along existing roads. This is the case in the Town of Kenduskeag.

Flood Damages

The streams studied in Kenduskeag have experienced flooding on numerous occasions. Flooding occurs on a nearly annual basis and sometimes two or three times per year. Flooding usually occurs during heavy rains in winter and spring. Ice and debris jams can further compound the problem.

Damage in the study areas is primarily to farmland, roads, bridges, and homes.

Flood damages consist of two main types:

- losses resulting from direct contact with flood water; and
- losses resulting from people being isolated due to the flooding of roads.

Damages resulting from direct contact with flood water include residential, agricultural, and road damages. Residential damage consists of flood water and deposition on the first floor and incidental damage to lawns and out buildings. **Table 1** shows the approximate number of buildings within the floodplain. All houses in the floodplain are in low hazard areas as defined by FEMA (see **Glossary** for definition). Agricultural damage consists of streambank erosion, deposition of sediment and debris on fields, and fence damage. Damages to state and town roads consist of debris and ice jam deposition, scour holes in the pavement, and washed out fill and culverts.

Floodplain Management Options

The management options that follow provide general information on the various means of flood protection and the reduction of monetary loss caused by floods. These options fall into two major categories: nonstructural and structural. Not all options will apply in Kenduskeag. With

further study, the Town or individuals may find viable options to reduce flood losses. Considerations in this evaluation include:

- whether the area is in a high or low hazard area;
- engineering feasibility;
- economics;
- effect on flooding elsewhere (induced flood damages); and
- social acceptability.

Nonstructural Measures

Nonstructural measures cannot prevent flooding, but they can help reduce future problems and monetary loss. The implementation of nonstructural measures should have little to no effect on the environment.

1. Floodproofing

Floodproofing is any measure that property owners may take to minimize flood damage to their property. The following are some of the more common means used to floodproof buildings:

- elevating the building above expected flood levels;
- application of waterproof sealant to foundations and permanent closing and sealing of lower openings;
- construction of earthen dikes or masonry floodwalls around the building to prevent water from entering it;
- installing water tight closures that can be quickly and easily placed over doors and windows;

- protection of appliances and utilities, such as furnaces, washers, dryers, and electrical and plumbing systems. Elevate the appliance or place it in a water proof bag to protect it from rising flood water.

Several buildings in Kenduskeag could benefit from floodproofing. Property owners should consider the following when selecting the most appropriate measure or combination of measures:

- the depth, velocity, and duration of flood flows;
- the benefit-to-cost ratio of the measure;
- engineering feasibility;
- soil types; and
- local codes and building restrictions.

The Federal Emergency Management Agency's (FEMA) publication, Design Manual for Retrofitting Flood-prone Structures, FEMA 114, 1986 contains additional information on floodproofing. Interested parties can order the publication at no cost by writing to the following address:

Federal Emergency Management Agency
P.O. Box 70274
Washington, DC 20024
Attn: Publications

2. Purchase or Relocation

In areas where all other means of flood protection are ineffective or impractical, federal and state funds may be available to buy properties or relocate buildings and their occupants. After removal of the buildings, use the land for recreation or some other purpose not significantly affected by floodwater.
This option applies to existing houses in the floodplain. This approach is most desirable from a floodplain management perspective, but it may not be socially acceptable.

3. Land Use Regulation

Use this option to keep future development out of the floodplain. The Town can acquire conservation, scenic, or flood control restrictions or easements in flood hazard areas where little or no development is desirable. Land use restrictions prevent development that is incompatible with public objectives, while allowing continued private ownership of the land. Certain future land rights, such as construction of buildings in the floodplain, could be purchased from present land owners. Permitted uses could be farming, wildlife, low intensity recreation, and woodland. Land use restrictions may also result in a lowering of the landowner's tax assessment.

In 1971 the State of Maine enacted the **Mandatory Zoning and Subdivision Control Law**, Chapter 424, Sections 4811 through 4814 of the Maine Statutes. The law requires all municipal units of government to adopt zoning and subdivision control ordinances for shoreland areas. Shoreland areas include land within 250 feet of the normal high water mark of any pond, river, or salt water body. This includes a major portion of the floodplain.

The Town should consider the preparation of an overall land use plan to enhance the natural and recreational values of the areas studied in Kenduskeag. The plan would set integrated objectives for public access, historic sites, recreational facilities, and the preservation of significant wildlife habitat areas.

Other general recommendations include:

- maintain wetland and floodplain vegetation buffers to reduce sedimentation and delivery of chemicals to the water body;

- support agricultural and forestry practices that minimize nutrient flows into water bodies;

- support proper use of pesticides and fertilizer;

- minimize soil erosion on land within, or adjacent to, floodplains, on forest road systems, and at timber harvesting operations; and

- dispose of spoil and waste material in a manner that would not contaminate ground and surface water or significantly change land contours.

Additional technical information on voluntary natural resource protection measures is available from the local PCSWCD office at 28 Gilman Plaza, Suite 2, in Bangor, telephone (207) 947-6622.

4. Flood Insurance

Kenduskeag has been a participant in the 'regular' phase of the National Flood Insurance Program (NFIP) since 1985. This program enables existing home owners within the 100-year floodplain to buy up to $245,000 worth of flood insurance on their home and contents at subsidized rates. Up to $550,000 worth of insurance can be obtained for multifamily homes and small businesses.

As part of the program, the Town must require a building permit for all proposed construction within flood-prone areas and review the permit to ensure that the site is reasonably free from flooding. It also must require that structures in flood-prone areas be properly anchored and that recommended construction materials and methods be used to minimize flood damage.

Home owners in flood prone areas should protect themselves from monetary loss with flood insurance. The Town should ensure that property owners in or next to the floodplain are aware of the availability of Federally subsidized flood insurance under the NFIP. Policies and information on coverage and rates are available from most insurance agents.

5. Floodways

Any encroachment in the floodplain will reduce its flood carrying capacity. Examples of encroachment include the placement of earthfill and the construction of buildings in the floodplain. The reduced capacity caused by the encroachment results in increased velocities and flood heights. Flood hazards, both upstream and downstream of the encroachment itself, generally increase.

One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood damages. Under this concept, the 100-year floodplain is divided into a floodway and a floodway fringe.

The floodway is the main channel of the watercourse plus any adjacent floodplain areas that must be clear to pass the 100-year flood without substantial increases in flood heights. FEMA minimum standards limit such increases in flood heights to 1.0 foot, provided that hazardous velocities do not result.

The floodway fringe includes the remainder of the floodplain that can be obstructed without increasing the 100-year flood elevation by more than 1.0 foot. This approach allows some development while protecting the existing floodplain. Typical relationships between the floodway the floodway fringe and their significance to floodplain management are shown in Figure 2.

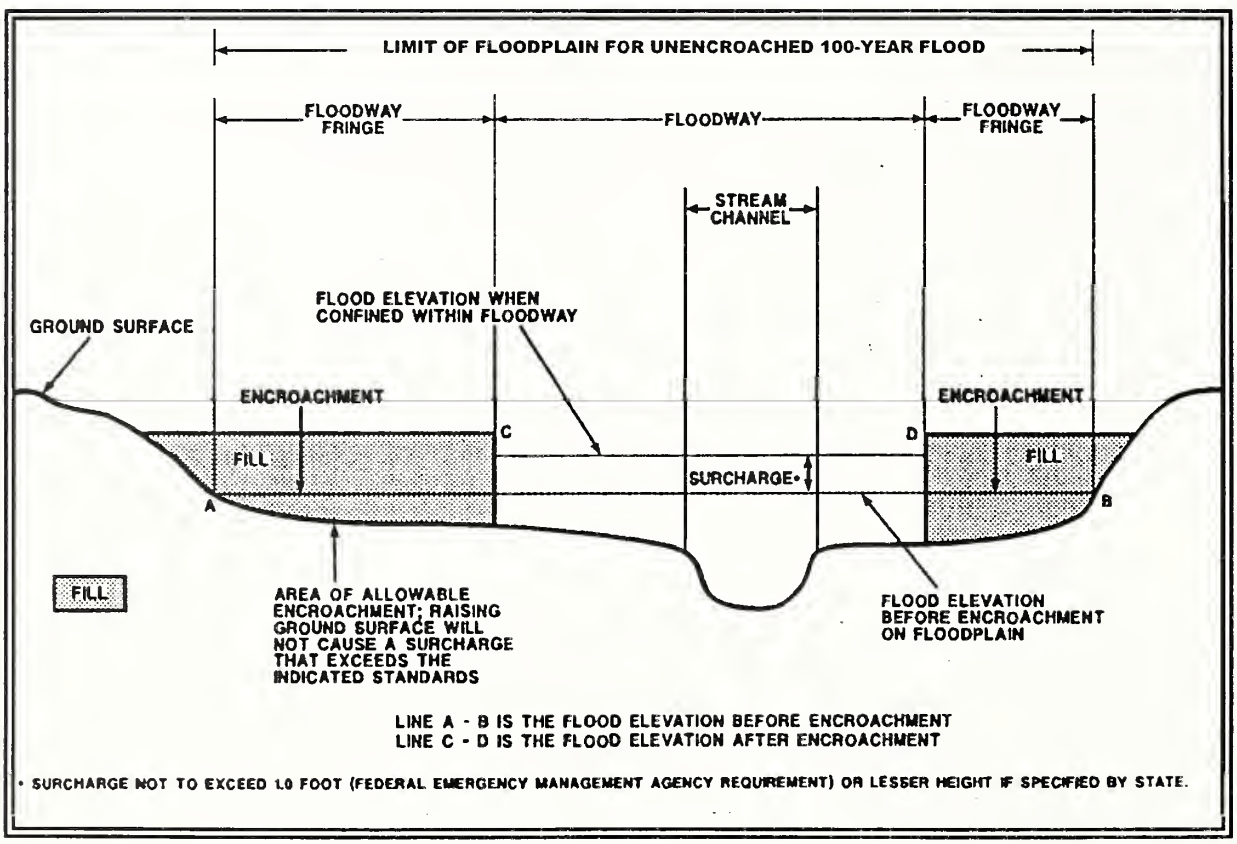

Figure 2 – Floodway Schematic

NRCS computed theoretical floodways for each of the streams studied in Kenduskeag considering equal flow reduction from each side of the floodplain. Floodway widths were computed at each cross section. Between cross sections, the floodway boundaries were interpolated. The computed floodways are shown on the Flood Hazard Area Maps (Appendix A). In cases where the floodway and 100-year floodplain boundaries are either close together or collinear, only the floodway boundary is shown. Floodway data for selected cross sections is presented in Table 6 "Floodway Data".

6. Warning Signs and Flood Markers

One proven method of discouraging floodplain development is to erect flood warning signs or markers in floodprone areas or to prominently post previous or predicted flood levels. This is a viable option for some stream crossings in Kenduskeag. These markers carry no enforcement, but simply serve to inform the public that a significant flood hazard exists.

7. Flood Warning and Response Systems

Flood warning and response systems use rainfall and channel water level information from upstream areas to predict flood stages downstream and provide early warning of a flood. This provides time for residents in the floodplain and emergency management agencies to evacuate people, animals, and belongings and otherwise prepare for the flood.

It is unlikely that a flood warning system could be economically justified in Kenduskeag.

8. Existing Roads

Table 4, **Bridge and Culvert Data**, shows the effects of flooding on bridges and culverts. Any planned road, culvert, or bridge work must involve detailed modeling of flood flows to determine the effects of flood heights on planned improvements and existing buildings in the floodplain. Raising roads may induce higher flood heights on buildings located upstream of or between a road and stream.

Table 6 - FLOODWAY DATA

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	SECTION WIDTH (FEET)	AREA (SQ FT)	MEAN VELOCITY (FPS)	REGULATORY	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY	INCREASE
KENDUSKEAG STREAM								
A	3,110[1]	314	3,387	2.8	106.8	106.8	107.8	1.0
B	3,285[1]	240	2,851	3.4	107.7	107.7	108.1	0.4
C	25,520[1]	281	2,361	3.5	121.5[2]	115.2	115.9	0.7
D	30,575[1]	100	1,271	4.7	122.2[2]	118.3	119.1	0.8
E	32,175[1]	104	1,017	6.7	123.0[2]	120.4	121.3	0.9
F	32,440[1]	189	2,360	2.4	123.5[2]	121.6	122.4	0.8
G	33,055[1]	136	940	6.0	124.1[2]	123.1	123.6	0.5
H	38,555[1]	165	1,639	3.4	126.8	126.8	127.7	0.9
I	42,755[1]	135	1,391	4.4	131.7	131.7	132.7	1.0
J	42,845[1]	151	1,696	3.4	132.1	132.1	133.0	0.9
K	44,390[1]	152	1,156	5.4	135.1	135.1	136.0	0.9
PIPER BROOK								
A	1,800[2]	51	307	6.4	145.5	145.5	146.3	0.8
B	4,400[2]	33	208	10.2	190.0	190.0	191.0	1.0
C	4,515[2]	109	697	3.1	198.4	198.4	198.4	0.0
PARTRIDGE BROOK								
A	4,400[2]	107	290	2.5	119.1	119.1	119.3	0.2
B	8,820[2]	111	635	1.1	159.0	159.0	159.9	0.9
C	11,020[2]	32	137	4.6	176.3	176.3	177.2	0.9
D	11,135[2]	320	1,467	0.5	179.0	179.0	179.0	0.0
E	12,355[2]	65	324	2.0	180.8	180.8	181.7	0.9
F	16,571[2]	359	1,551	0.3	231.2	231.2	231.2	0.0

[1] Feet above town line.
[2] Based on historic ice jam information.
[3] Feet above confluence with Kenduskeag Stream.

The Town needs to explore the cost-to-benefit ratio for any planned road work.

Structural Measures

Structural measures generally include such options as dams, channel work, removal of channel restrictions, and dikes. They require in-depth engineering, environmental, and economic analyses beyond the scope of this study to determine feasibility. Structural measures tend to have significant environmental impacts. The following discussion considers each measure as it might apply to Kenduskeag.

1. Dams

Dams control flood flows by temporarily storing storm runoff in a reservoir and releasing it slowly after the storm has passed. Dams are expensive to build and have significant environmental impacts. A flood control dam could not be justified based on the damages in the areas studied.

2. Channel Work

The purpose of channel work is to improve the flood carrying capacity and reduce flood damage along a given stream segment. This work can involve changing the alignment, widening, deepening, or lining the channel.

Major channel work of any kind would be difficult to permit in Maine because of severe environmental impacts. Historically, such efforts have resulted in controversy over the effects on fishery resources. Close coordination with interested agencies and groups would be required to determine the feasibility of this option.

3. Removal of Channel Restrictions

Bridges and culverts are the primary restrictions on the streams in Kenduskeag. Many are undersized or have inefficient inlet configurations and act as barriers to flood flows. The result is increased flow depths upstream of the bridge or culvert. As improvement funds become available, the Town and state should take action to increase bridge and culvert openings to increase discharge capacities.

Table 3, **Summary of Discharges**, provides peak discharge data at bridge and culvert locations. Table 4, **Bridge and Culvert Data**, compares flood elevations to the low chord and road overflow elevations. The data shows that improvements are necessary, particularly on the smaller streams and at private crossings. The **Flood Profiles** provide a graphical presentation of the effects of these restrictions on upstream flood elevations. A bridge or culvert failure can cause debris to block the channel and/or damage other structures.

State and local road maintenance crews should remove trees, sediment, ice or other debris from all bridges and culverts before spring runoff. Pay particular attention to the smaller stream crossings that have a history of flood problems.

4. Dikes

A dike is an earthen embankment used as a barrier to protect structures from flood water. Any planned dike work must involve detailed modeling of flood flows to determine the effects of flood heights on existing structures in the floodplain.

GLOSSARY

CFS or cfs - Cubic feet per second. Used to describe the amount of flow passing a given point in a stream channel. One cubic foot per second is equivalent to approximately 7.5 gallons per second.

Channel - A natural or artificial watercourse with definite bed and banks to conduct and confine flowing water.

Cross Section - A graph or plot of ground elevation across a stream valley or a portion of it, usually along a line perpendicular to the stream or direction of flow.

Erosion - The group of processes whereby soil or rock material becomes loosened or dissolved and removed from any part of the earth's surface.

Flood - An overflow or inundation onto land areas not normally covered by water that are used or usable by people. Floods usually are characterized as temporarily inundating land areas which are adjacent to a body of water such as an ocean, lake, stream, or river.

Flood Crest - The maximum stage or elevation reached by the waters of a flood at any location.

Floodplain - The relatively flat area of lowlands adjoining the channel of a river, stream, watercourse, ocean, lake, or other body of standing water that has been or may be covered by floodwater.

Floodplain Management - The operation of a program intended to lessen the damaging effects of floods, maintain and enhance natural values, and make effective use of water and land resources within the floodplain. It is an attempt to balance values obtainable from use of floodplains with potential losses arising from such use. Floodplain management stresses consideration of a full range of the measures potentially useful in achieving its objectives.

Flood Hazard Area Map - A map showing the lateral extent of flooding. Maps in this report show the 100-, and 500-year floodplains.

Flood Profile - A graph that shows the relationship of water surface elevation to distance along the centerline of the channel. This report uses profiles to show the crest elevations of 10-, 50-, 100-, and 500-year floods.

Floodproofing - A combination of structural changes or adjustments to new or existing structures and facilities, their contents or their sites for the purpose of reducing or eliminating flood damages by protecting against structural failure, keeping water out, or reducing the effect of water entry.

Flood Warning - The issuance and dissemination of information about an imminent or current flood.

Floodway - That portion of the main stream channel plus any adjacent floodplain areas that must be kept free of encroachment in order that the 100-year flood can be carried without substantial increases in flood heights.

Floodway Fringe - That part of the floodplain that can be completely obstructed without increasing the 100-year flood elevation by more than 1.0 foot at any point.

Frequency - A statistical measure of how often a flood event of a given size or magnitude should, on the average, be equaled or exceeded.

Head - The height of water above any plane of reference.

Head Loss - The effect of obstructions, such as narrow bridge openings or buildings, that limit the area through which water must flow, raising the surface of the water upstream of the obstruction.

High Hazard Zone - An area, normally nearest the stream, where flooding may pose a significant risk to life and property. Areas having any one of the following conditions generally are considered high hazard:

- Areas where flood velocities exceed 5 feet per second (fps).
- Areas where flood depths are greater than 3 feet.

- Areas where the product of the velocity (in fps) and the depth (in feet) of the flood water exceeds seven.

Low Chord - The elevation at which a bridge girder first begins to reduce the flow area of the channel.

Low Hazard Zone - The area between the high hazard zone and the maximum extent of the 100-year frequency flood where the potential for loss of life and property damage is low.

Natural Values of Floodplains - The desirable qualities of, or functions served by, floodplains including, but not limited to: water resources values (e.g. -- moderation of floods, water quality maintenance, and ground water recharge); living resource values (e.g. -- fish, wildlife, plant resources, and habitat); cultural resource values (e.g. -- open space, natural beauty, scientific study, outdoor education, and recreation); and cultivated resources values (e.g. -- agricultural, aquacultural, and forestry).

NGVD - National Geodetic Vertical Datum, formerly Mean Sea Level (MSL) 1929.

Nonstructural Measures - All floodplain management measures except structural flood control works. Examples of nonstructural measures are flood warning and preparedness systems, relocation, floodproofing, regulation, land acquisition, and public investment policy.

Relocation - Moving a building from a flood prone area by physically placing it on a vehicle and transporting it from the floodplain.

Road Overflow - The elevation of the point at which water first starts to flow over a road.

Shoreland Areas - Land within 250 feet of the normal high water mark of any pond, river, or salt water body, including a major portion of the floodplain.

Station - Distance in feet along the centerline of the existing channel, increasing in an upstream direction.

Structural Measure - Flood control works such as dams and reservoirs, dikes and floodwalls, channel alterations, and diversion channels which are designed to keep water away from specific developments or populated areas, or to reduce flooding in such areas.

Wetland - Areas that have a predominance of hydric soils and that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and under normal circumstances do support a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions.

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3. ----------, September 1982, Maine Hydrologic Units and Their Drainage Areas, Orono, ME.

4. ----------, October 1993, National Engineering Handbook (NEH), Part 630, Chapter 31, Computer Program For Water Surface Profiles (WSP), Washington, DC.

5. U.S. Department of Commerce, Bureau of the Census, unpublished, 1990 Census of Population, Number of Inhabitants, Maine, U.S. Government Printing Office, Washington, DC.

6. U.S. Department of the Interior, Geological Survey, 7.5 Minute Series Topographic Map, Scale 1:24,000, Contour Interval 10 Feet, Kenduskeag, Maine, 1977

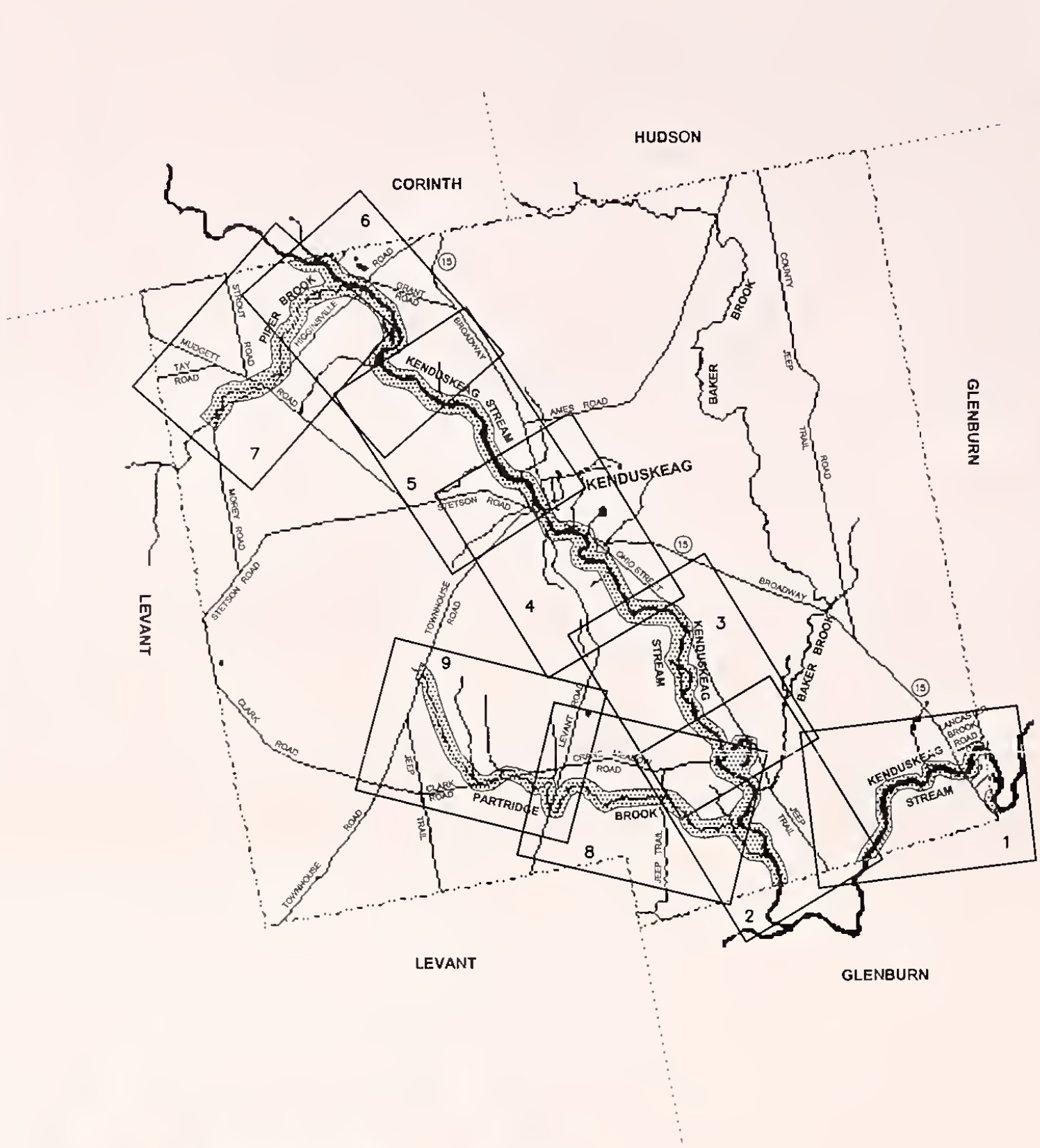
Civil Rights Impact Analysis

The NRCS official responsible for the civil rights impact analysis for this FPMS has determined that civil rights impacts have been identified and adequately addressed. No protected groups will be negatively or disproportionately impacted as a result of recommendations included in this study.

APPENDIX A
FLOOD HAZARD AREA MAPS

U.S. DEPARTMENT OF AGRICULTURE

NATURAL RESOURCES CONSERVATION SERVICE



APPROXIMATE SCALE

4,000 0 2,000 4,000 8,000

(IN FEET)

1 Inch = 4,000ft.

1 SHEET COVERAGE

STREAM REACH STUDIED

PENOBSCOT COUNTY

LOCATION MAP

INDEX TO MAP SHEETS

KENDUSKEAG FLOODPLAIN MANAGEMENT STUDY

PENOBSCOT COUNTY, MAINE

SOURCE:

BASE COMPILED FROM 1:24,000 USGS QUADRANGLES AND INFORMATION FROM NRCS FIELD PERSONNEL.

MAY 1999

LEGEND

106 — 100-Year Flood Elevation

Floodway

A — Valley Section Location

Elevation Reference Mark

NOTE:
LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT. THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION.
1998 USDA - NRCS AERIAL PHOTOGRAPHY

0 500 1000
APPROXIMATE SCALE IN FEET

A-1

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TOWN OF KENDUSKEAG
FLOODPLAIN MANAGEMENT STUDY
PENOBSCOT COUNTY, MAINE

FLOOD HAZARD AREA

KENDUSKEAG STREAM

LEGEND

- 112 — 100-Year Flood Elevation
- Floodway
- C — Valley Section Location
- Elevation Reference Mark

NOTE:
LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT. THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION.
1998 USDA - NRCS AERIAL PHOTOGRAPHY

0 500 1000
APPROXIMATE SCALE IN FEET

A - 2

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PENOBSCOT COUNTY, MAINE

FLOOD HAZARD AREA

KENDUSKEAG STREAM

LEGEND

113 — 100-Year Flood Elevation

Floodway

C — Valley Section Location

▲ — Elevation Reference Marks

NOTE:
LIMITS OF FLOOOING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUNO OUE TO INHERENT AERIAL PHOTOGRAPHIC OISPLACEMENT. THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUNO LOCATION.
1998 USOA · NRCS AERIAL PHOTOGRAPHY

0 500 1000
APPROXIMATE SCALE IN FEET

A-3

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PENOBSCOT COUNTY, MAINE

FLOOD HAZARD AREA

KENDUSKEAG STREAM

LEGEND

122 — 100-Yeer Flood Elevation

Floodway

D — Valley Section Location

Elevation Referanca Mark

NOTE:
LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT. THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION.
1998 USDA - NRCS AERIAL PHOTOGRAPHY

0 500 1000
APPROXIMATE SCALE IN FEET

A - 4

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PENOBSCOT COUNTY, MAINE

FLOOD HAZARD AREA

KENDUSKEAG STREAM

LEGEND

124 — 100–Year Flood Elevation

– – – – Floodway

H — Valley Section Location

▲ — Elevation Reference Mark

NOTE:
LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT. THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION.
1998 USDA - NRCS AERIAL PHOTOGRAPHY

0 500 1000
APPROXIMATE SCALE IN FEET

A - 5

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PENOBSCOT COUNTY, MAINE

FLOOD HAZARD AREA

KENDUSKEAG STREAM

LEGEND

128 — 100-Year Flood Elevation

Floodway

H — Valley Section Location

Elevation Reference Mark

NOTE:
LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT. THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION.
1998 USDA - NRCS AERIAL PHOTOGRAPHY

0 500 1000
APPROXIMATE SCALE IN FEET

A-6

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PENOBSCOT COUNTY, MAINE

FLOOD HAZARD AREA

KENDUSKEAG STREAM

LEGEND

135 — 100-Year Flood Elevation

Floodway

A — Valley Section Location

Elevation Reference Mark

NOTE:
LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT. THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION.
1998 USDA - NRCS AERIAL PHOTOGRAPHY

0 500 1000
APPROXIMATE SCALE IN FEET

A-7

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PENOBSCOT COUNTY, MAINE

FLOOD HAZARD AREA

PIPER BROOK

LEGEND

458 — 100–Yeor Flood Elevotion

– – – – Floodway

(A) — Volley Section Location

▲ Elevotion Reference Mork

NOTE:
LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT. THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION.
1998 NRCS - USDA AERIAL PHOTOGRAPHY

0 500 1000
APPROXIMATE SCALE IN FEET

A-8

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FLOODPLAIN MANAGEMENT STUDY
PENOBSCOT COUNTY, MAINE

FLOOD HAZARD AREA

PARTRIDGE BROOK

LEGEND

458 — 100-Year Flood Elevation

– – – – Floodway

(A) — Valley Section Location

▲ — Elevation Reference Mark

NOTE:
LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT. THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION.
1998 NRCS – USDA AERIAL PHOTOGRAPHY

0 500 1000
APPROXIMATE SCALE IN FEET

A-9

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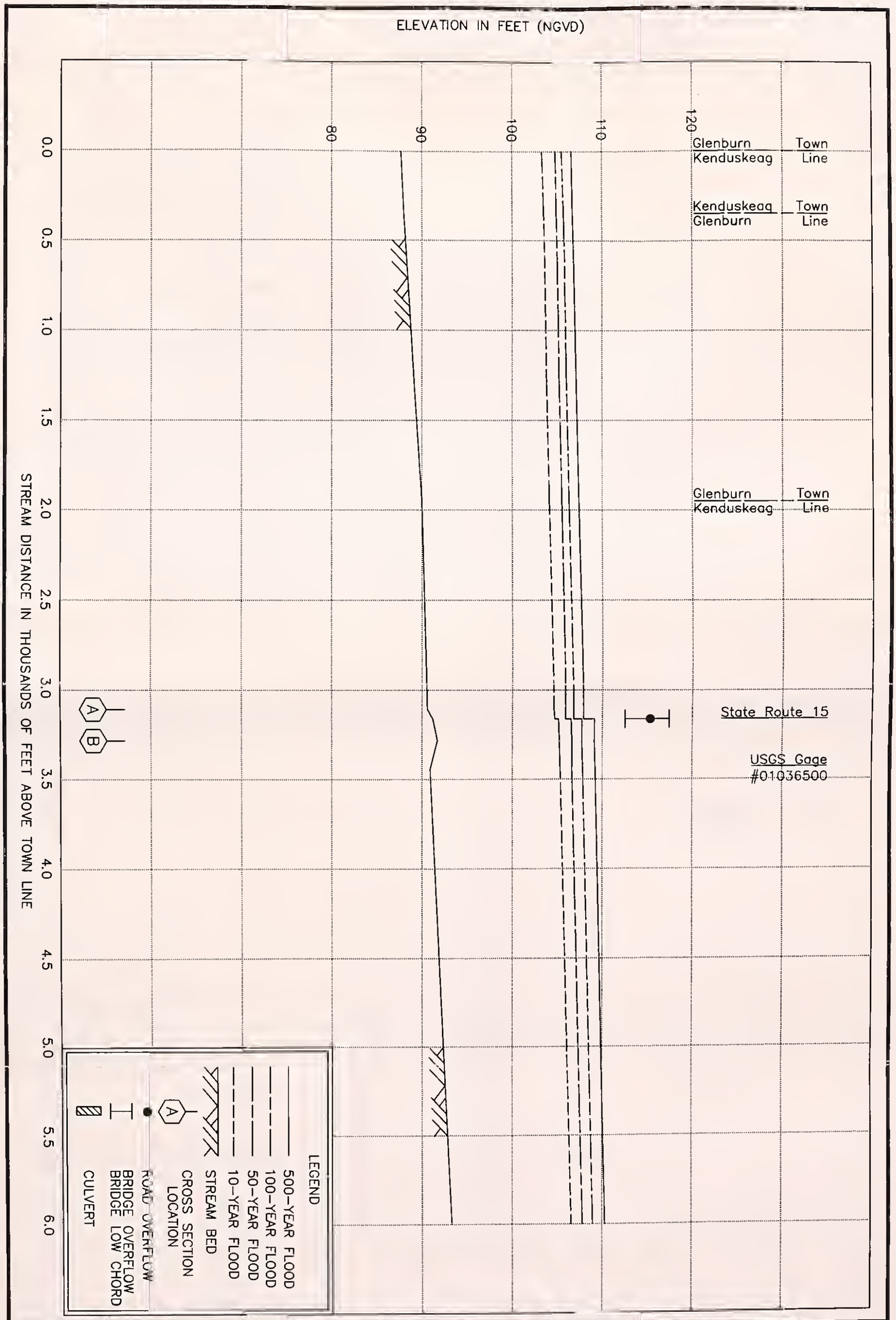
PENOBSCOT COUNTY, MAINE

FLOOD HAZARD AREA

PARTRIDGE BROOK

APPENDIX B
FLOOD PROFILES



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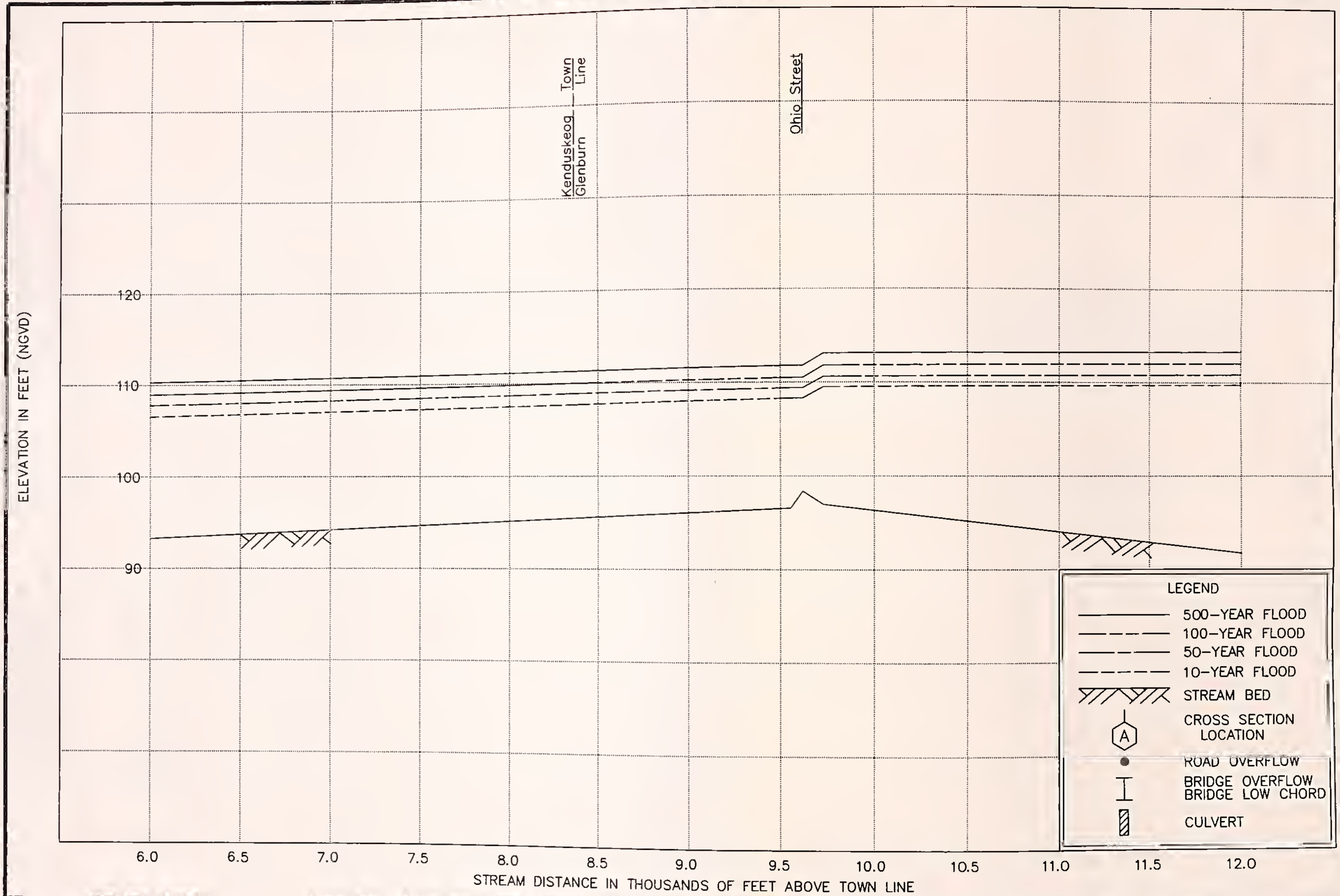
FLOODPLAIN MANAGEMENT STUDY
PENOBSCOT COUNTY, MAINE

FLOOD PROFILES
KENDUSKEAG STREAM



FLOOD PROFILES
KENDUSKEAG STREAM

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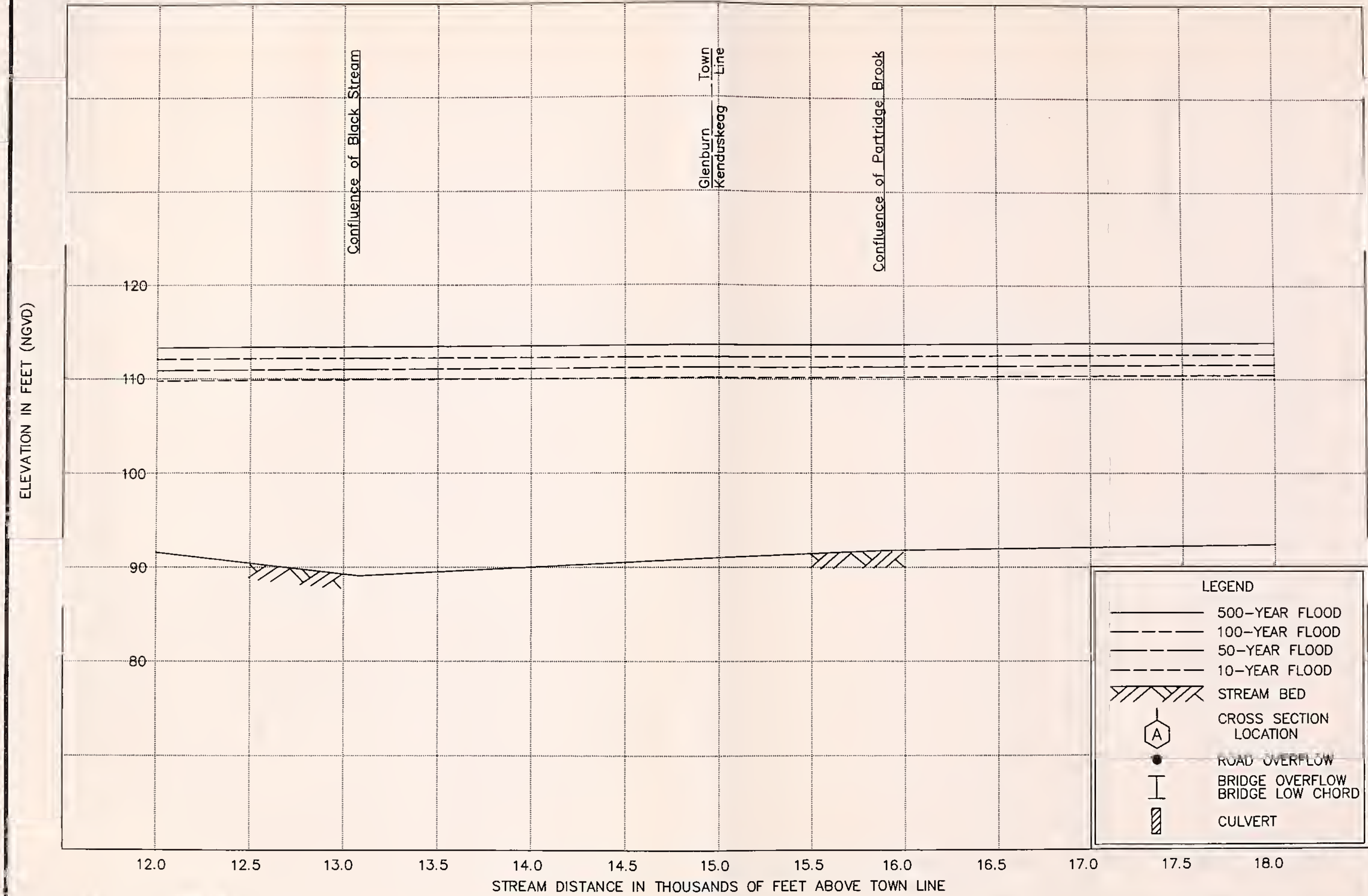
TOWN OF KENDUSKEAG
FLOODPLAIN MANAGEMENT STUDY
PENOBSCOT COUNTY, MAINE

B - 2



FLOOD PROFILES
KENDUSKEAG STREAM

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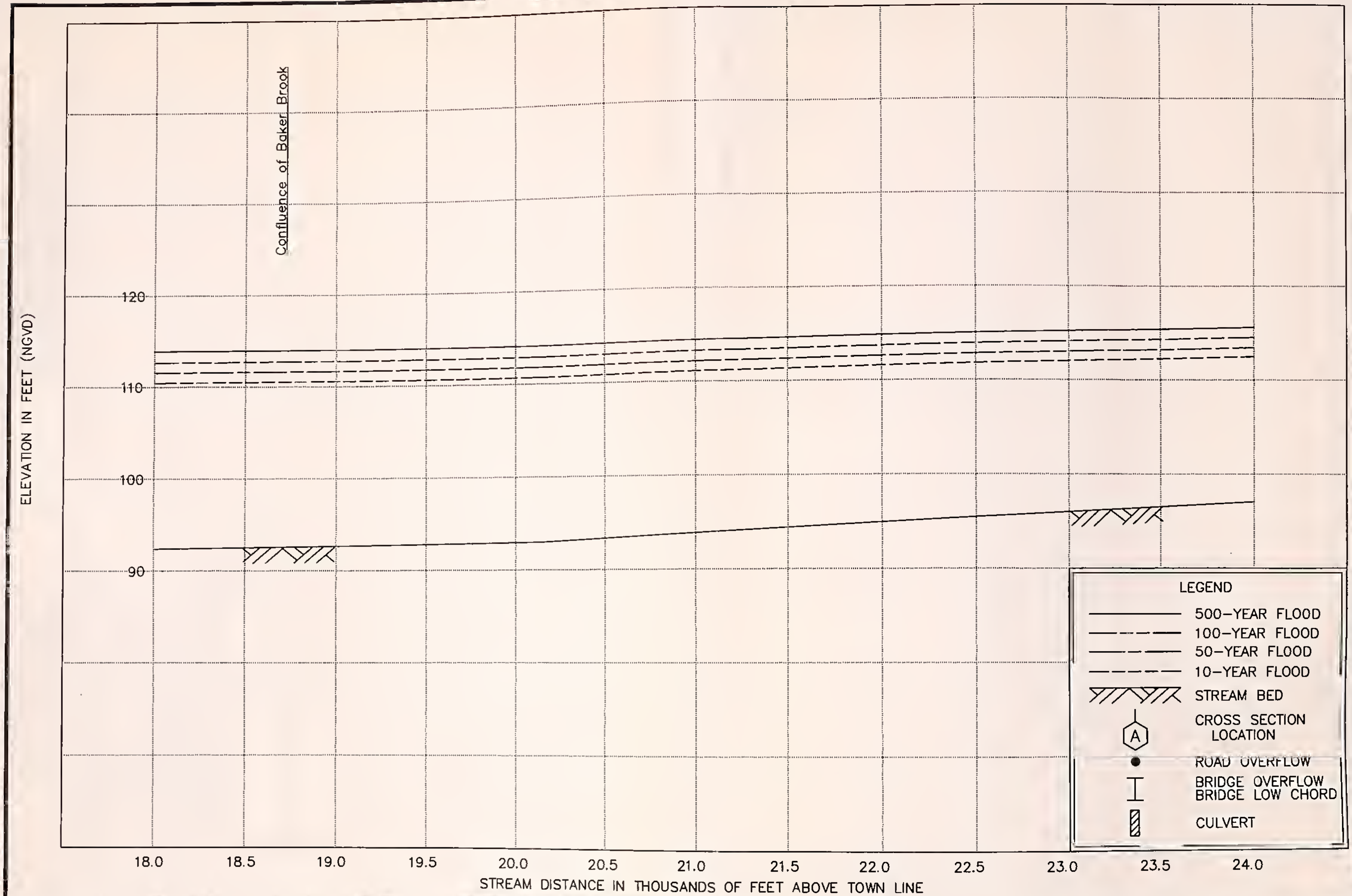
NATURAL RESOURCES CONSERVATION SERVICE
TOWN OF KENDUSKEAG
FLOODPLAIN MANAGEMENT STUDY
PENOBSCOT COUNTY, MAINE



FLOOD PROFILES
KENDUSKEAG STREAM

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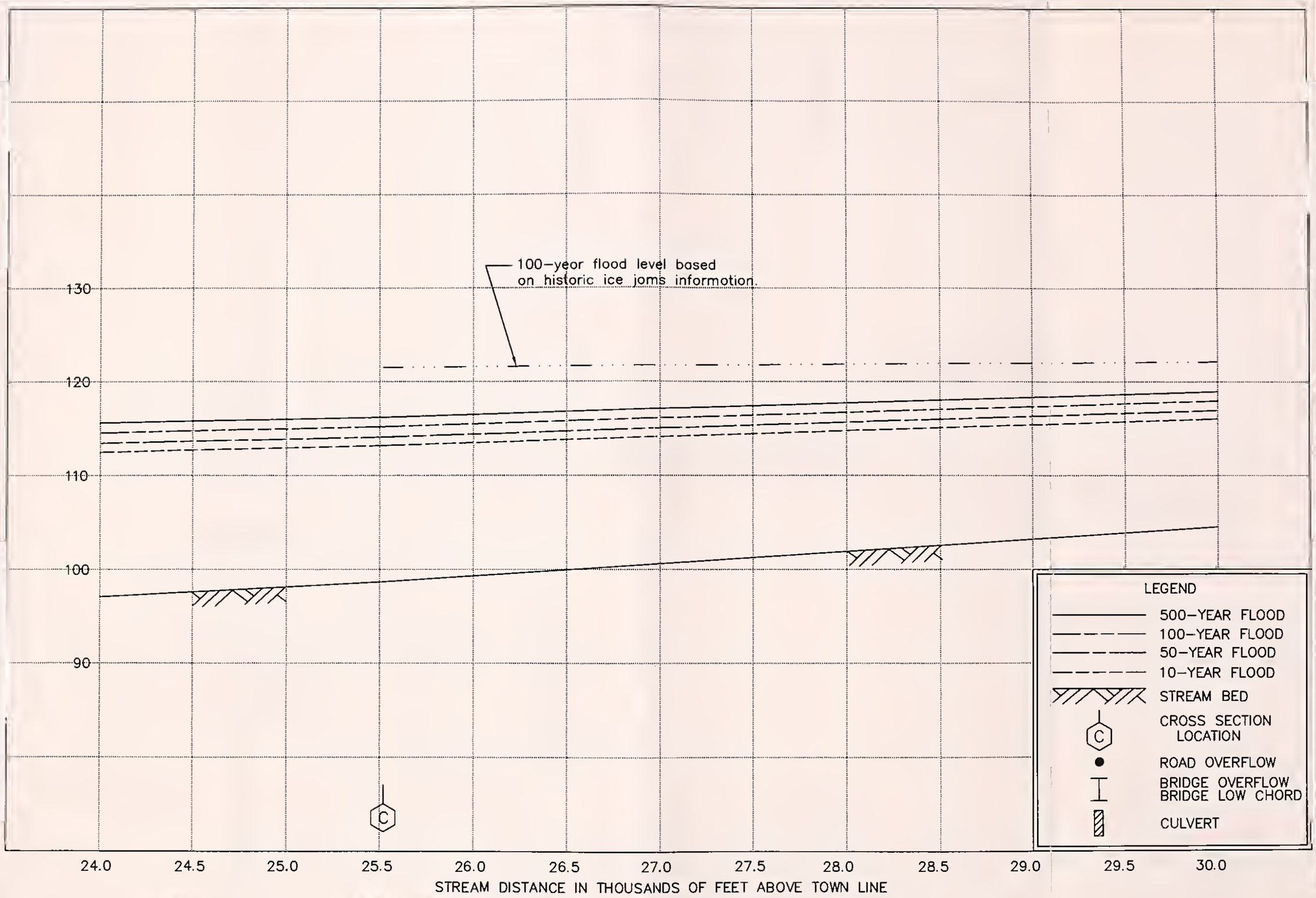
PENOBSCOT COUNTY, MAINE

FLOOD PROFILES
KENDUSKEAG STREAM



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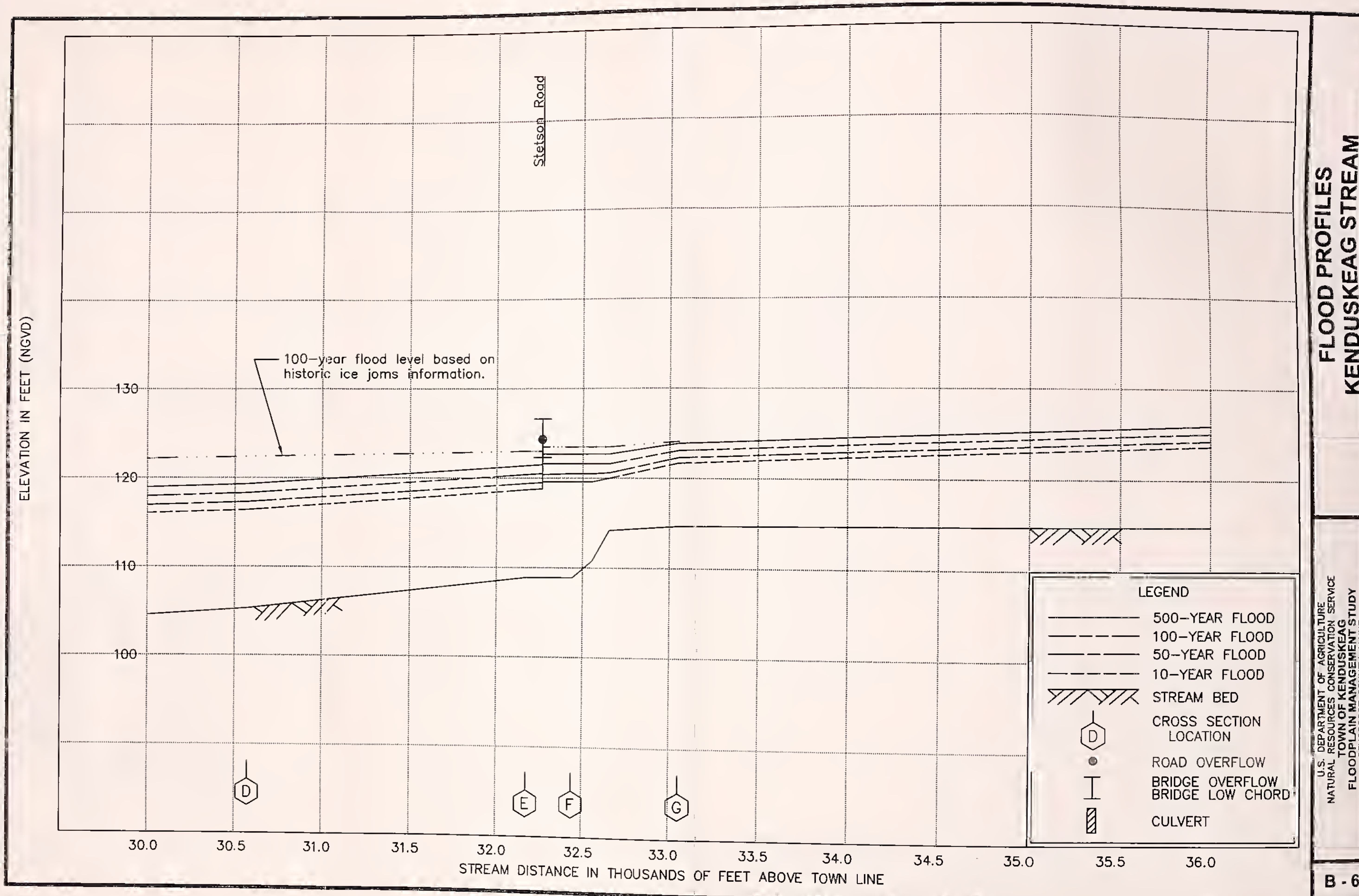
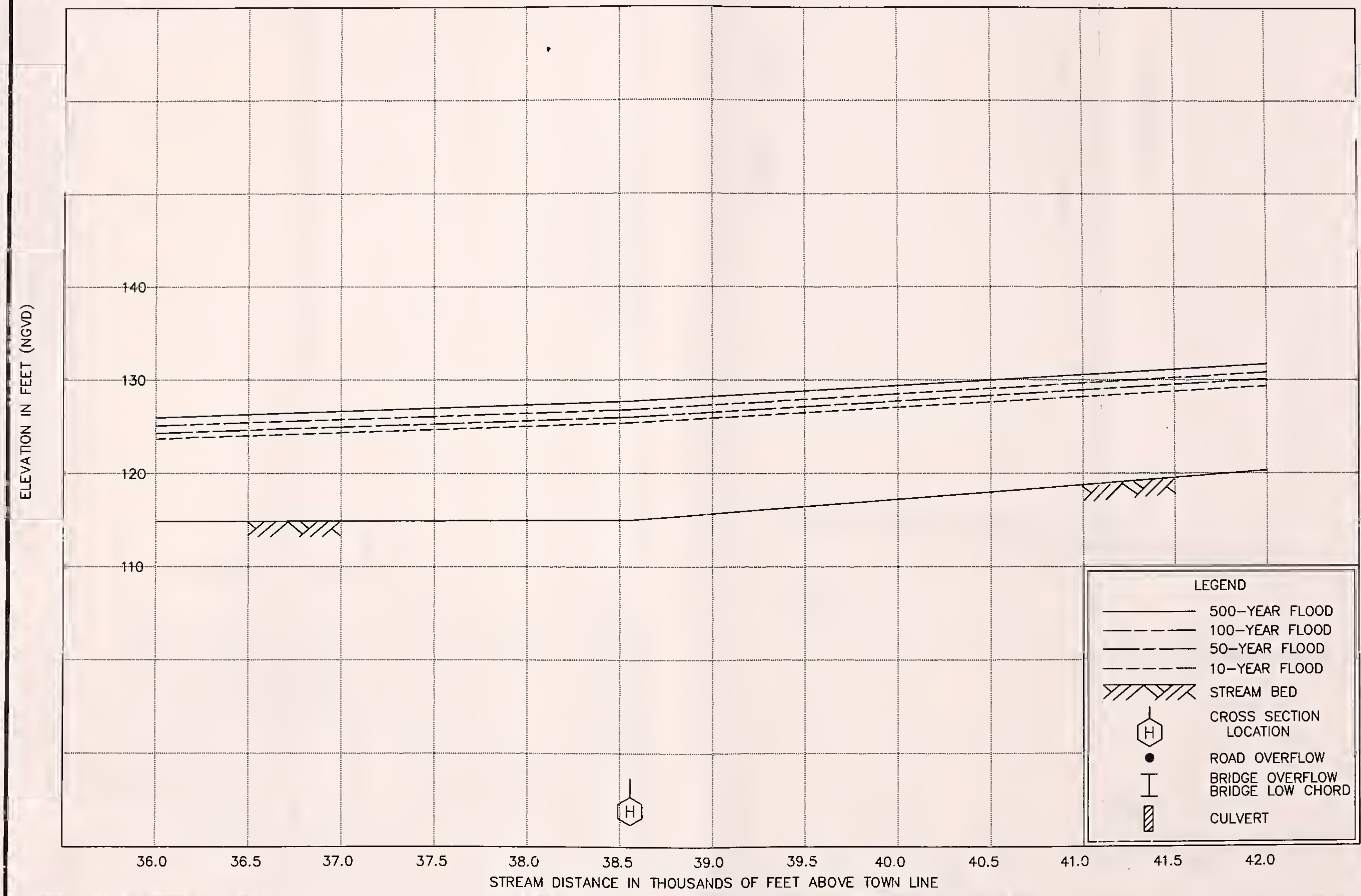


FLOOD PROFILES
KENDUSKEAG STREAM
Stetson Road
100-year flood level based on historic ice joms information.
ELEVATION IN FEET (NGVD)
130
120
110
100
30.0
30.5
31.0
31.5
32.0
32.5
33.0
33.5
34.0
34.5
35.0
35.5
36.0
STREAM DISTANCE IN THOUSANDS OF FEET ABOVE TOWN LINE
D
E
F
G
LEGEND
500-YEAR FLOOD
100-YEAR FLOOD
50-YEAR FLOOD
10-YEAR FLOOD
STREAM BED
CROSS SECTION LOCATION
ROAD OVERFLOW
BRIDGE OVERFLOW
BRIDGE LOW CHORD
CULVERT
U.S. DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
TOWN OF KENDUSKEAG
FLOODPLAIN MANAGEMENT STUDY
PENOBSCOT COUNTY, MAINE
B - 6

FLOOD PROFILES
KENDUSKEAG STREAM



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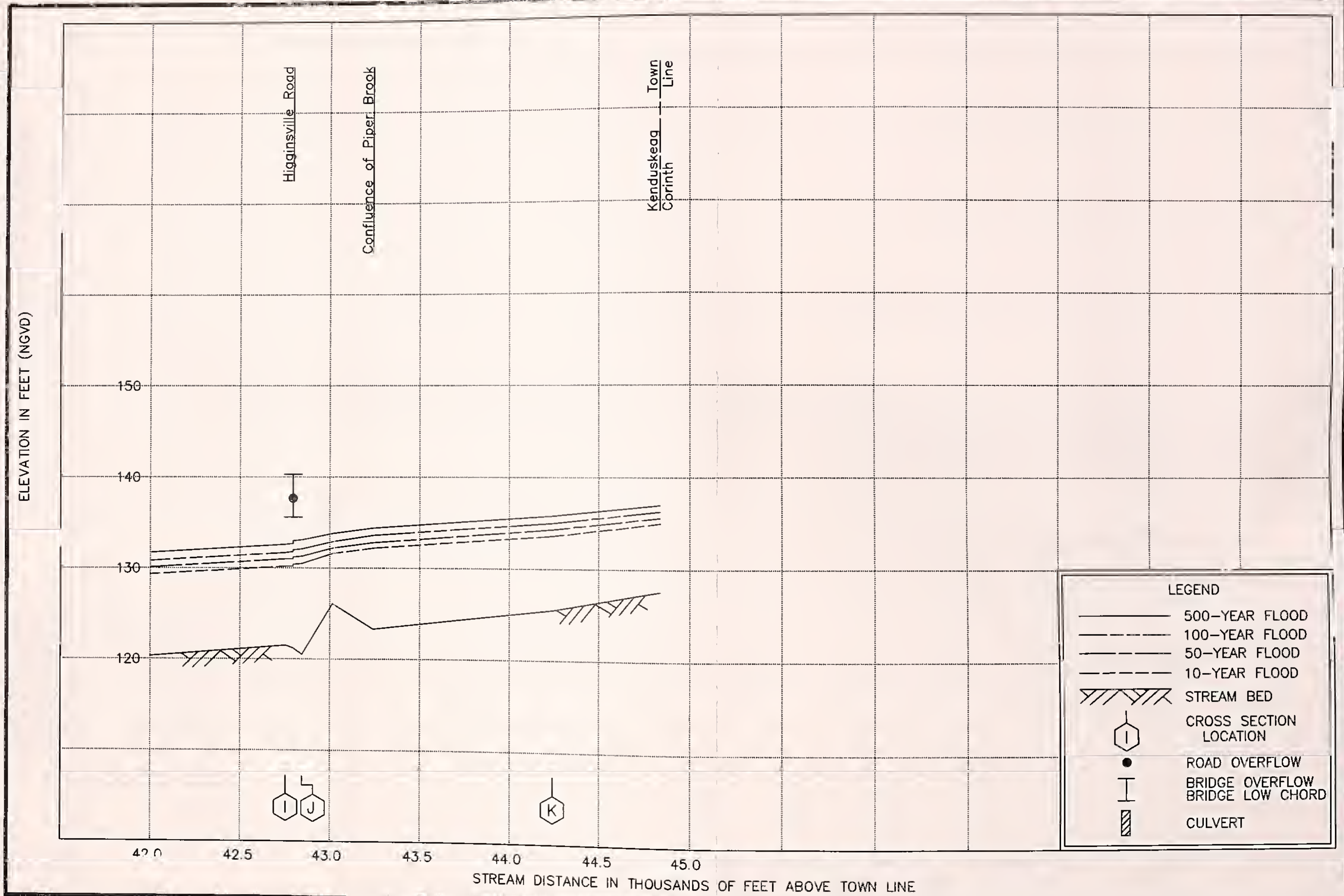

FLOOD PROFILES
KENDUSKEAG STREAM

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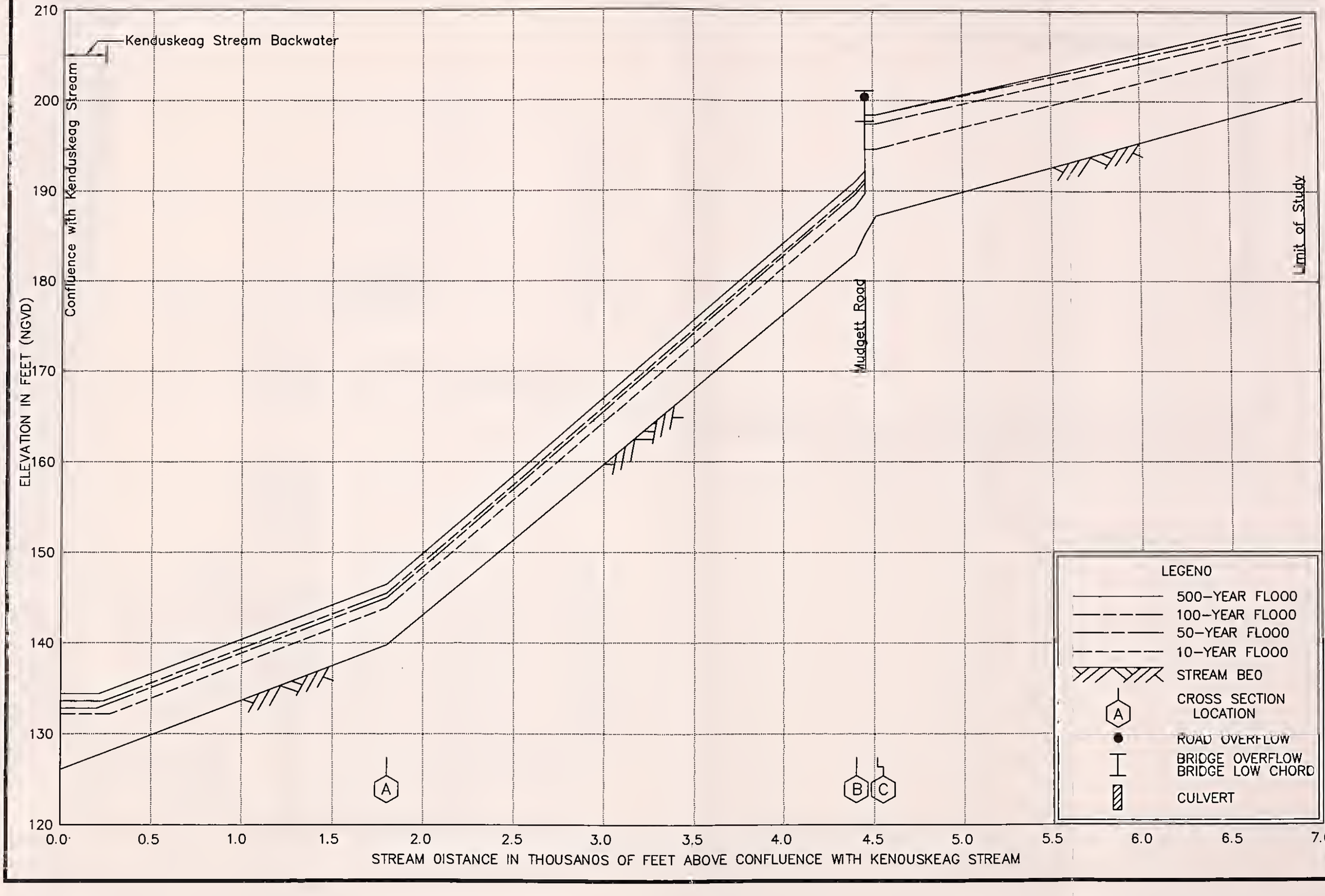
PENOBSCOT COUNTY, MAINE

FLOOD PROFILES
PIPER BROOK



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TOWN OF KENDUSKEAG
FLOODPLAIN MANAGEMENT STUDY
PENOBSCOT COUNTY, MAINE

FLOOD PROFILES
PARTRIDGE BROOK

Kenduskeag Stream Backwater

Confluence with Kenduskeag Stream

Snowmobile Trail

THE 50-YEAR PROFILE IS TOO CLOSE TO THE 100-YEAR ELEVATION TO BE SHOWN SEPARATELY.

ELEVATION IN FEET (NGVD)

130
120
110
100
90

0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0

STREAM DISTANCE IN THOUSANDS OF FEET ABOVE CONFLUENCE WITH KENDUSKEAG STREAM

A

LEGEND

- 500-YEAR FLOOD
- 100-YEAR FLOOD
- 50-YEAR FLOOD
- 10-YEAR FLOOD
- STREAM BED
- CROSS SECTION LOCATION (A)
- ROAD OVERFLOW
- BRIDGE OVERFLOW BRIDGE LOW CHORD
- CULVERT

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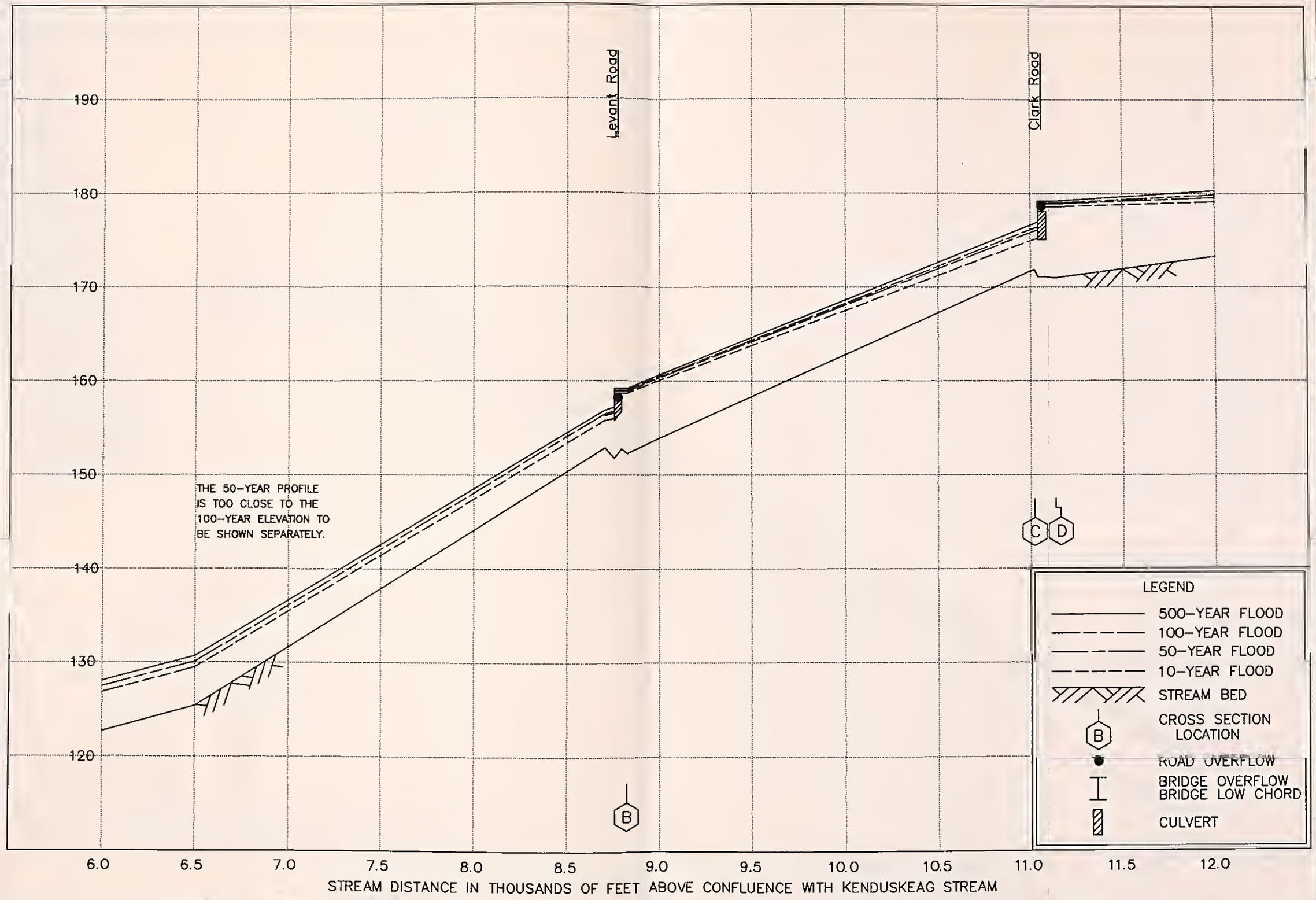
TOWN OF KENDUSKEAG
FLOODPLAIN MANAGEMENT STUDY
PENOBSCOT COUNTY, MAINE

FLOOD PROFILES
PARTRIDGE BROOK



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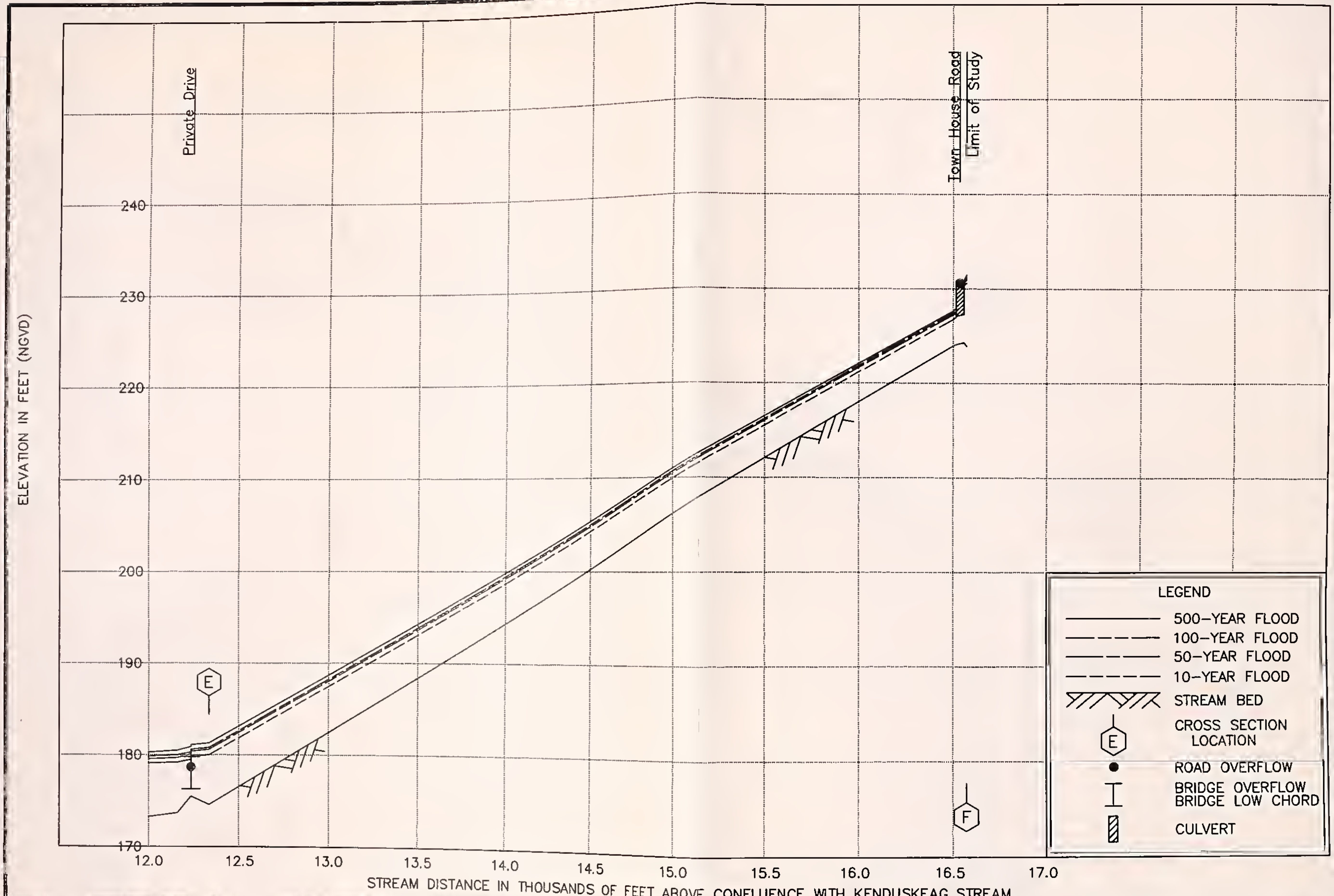
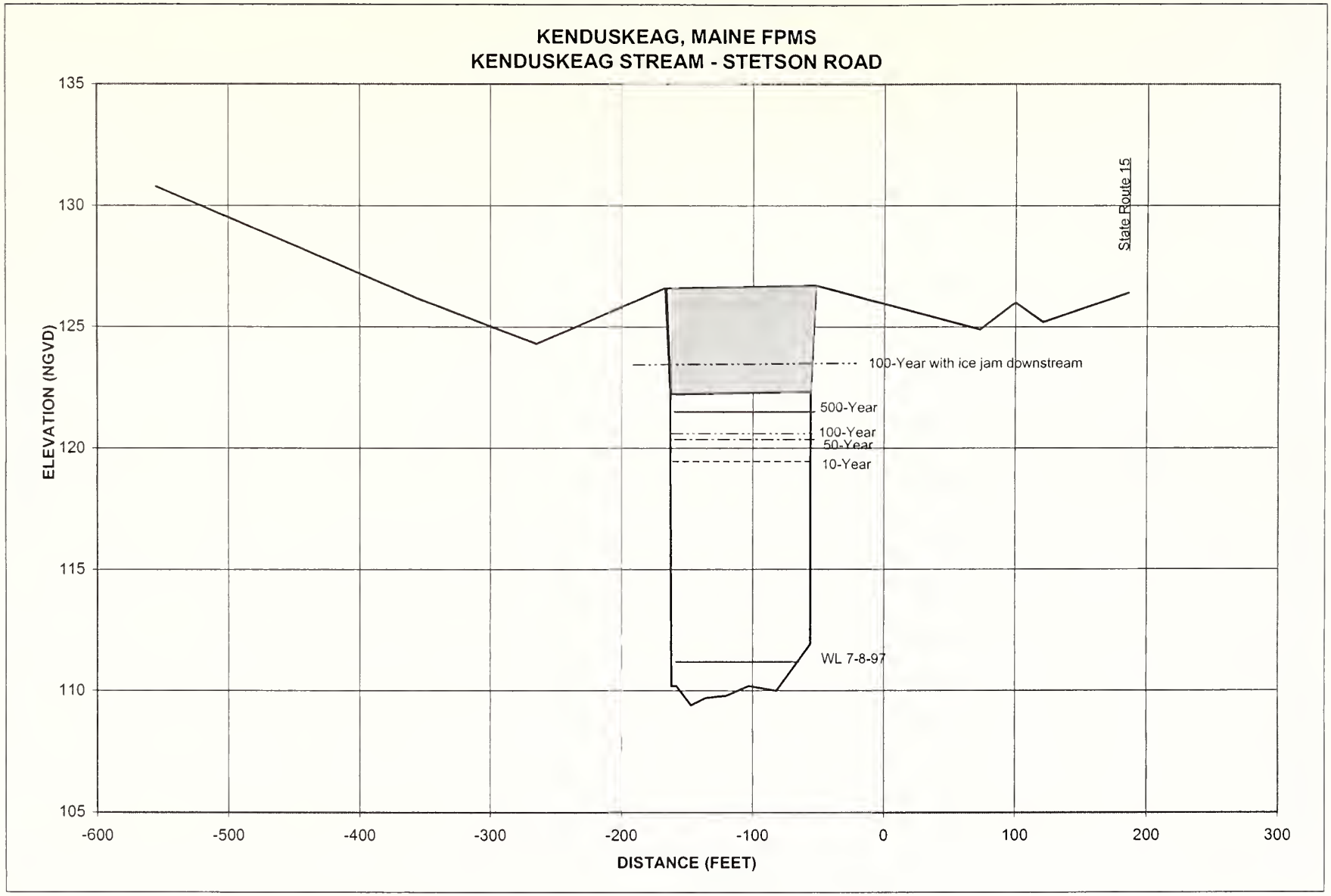
FLOODPLAIN MANAGEMENT STUDY
PENOBSCOT COUNTY, MAINE

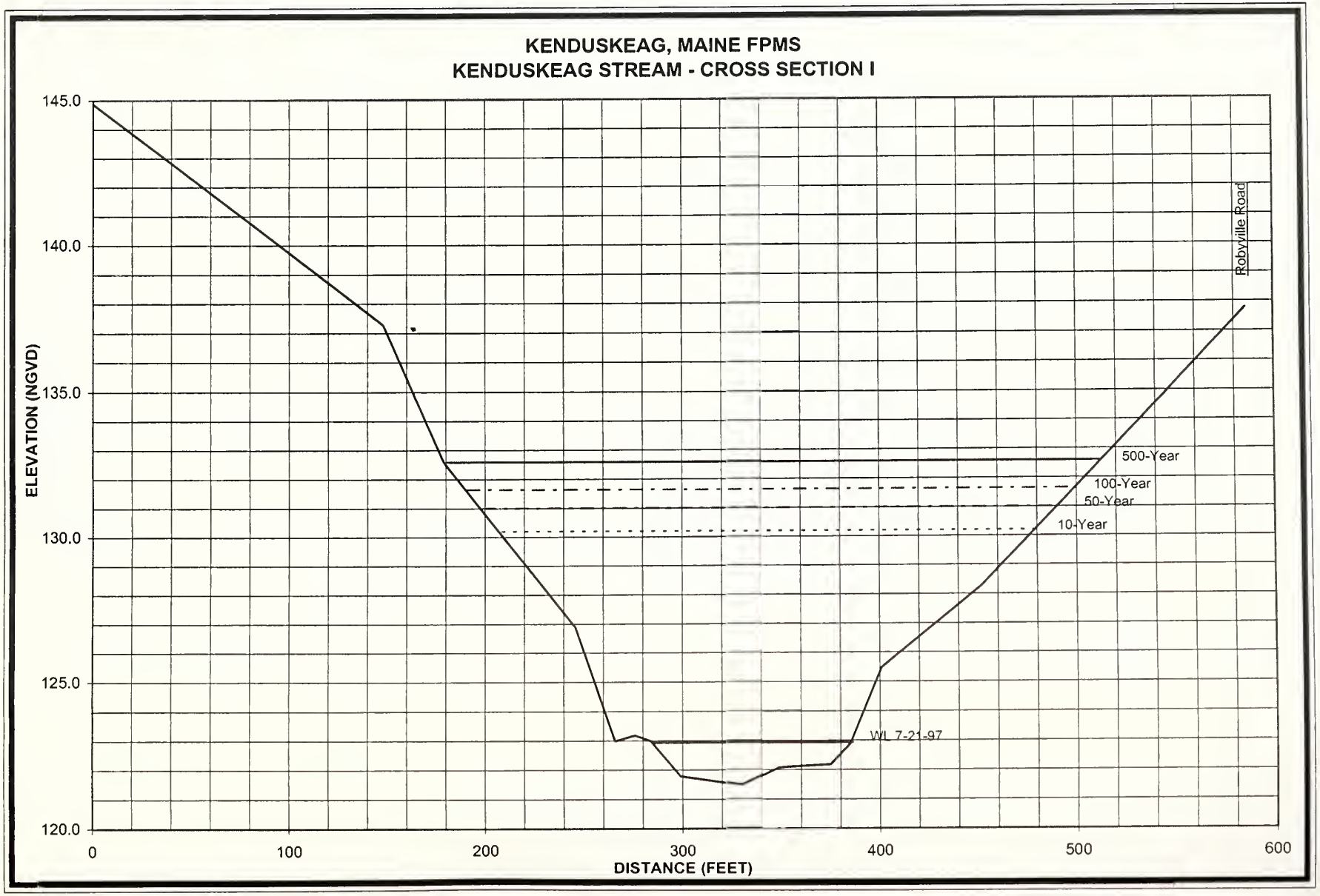


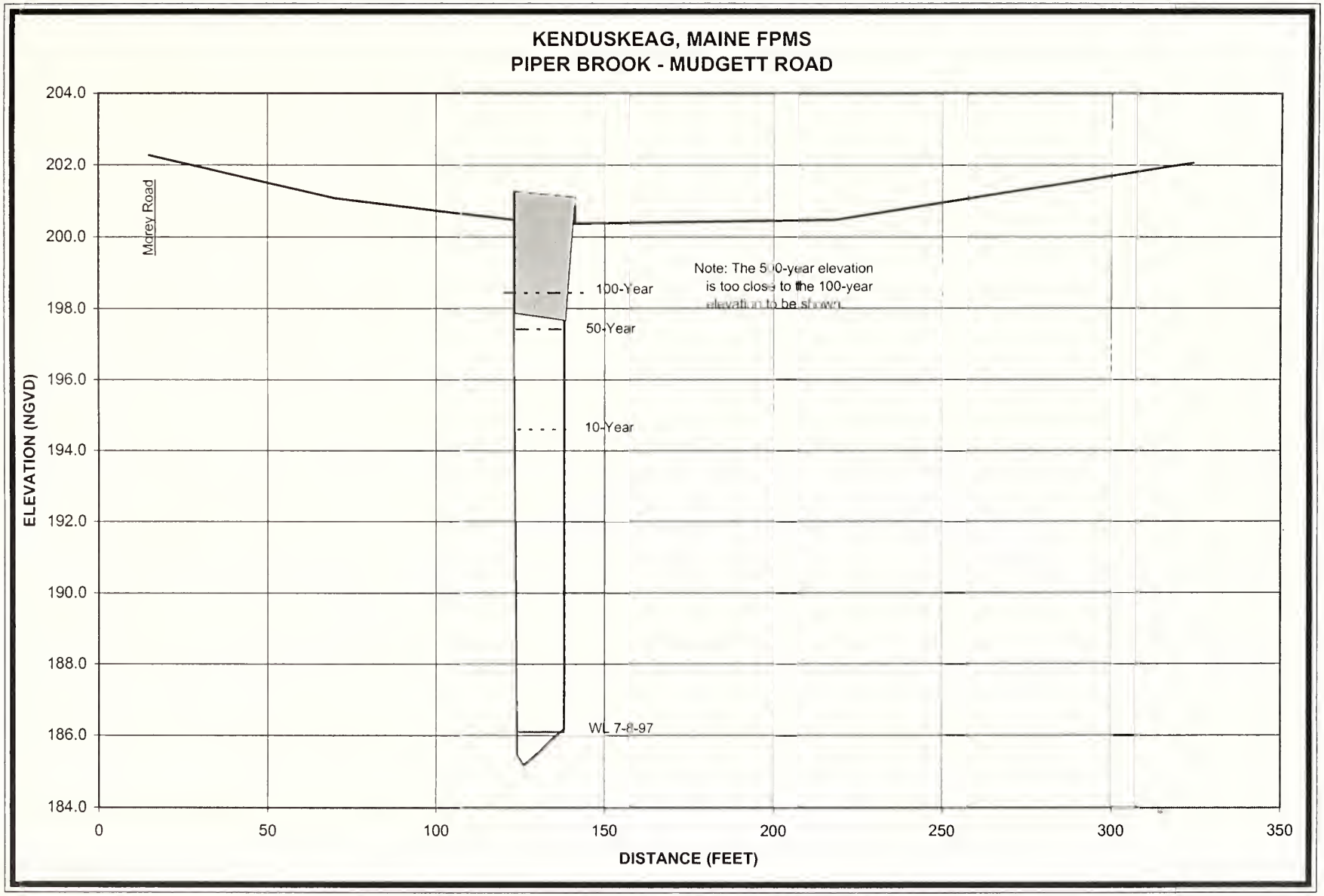
FLOOD PROFILES
PARTRIDGE BROOK

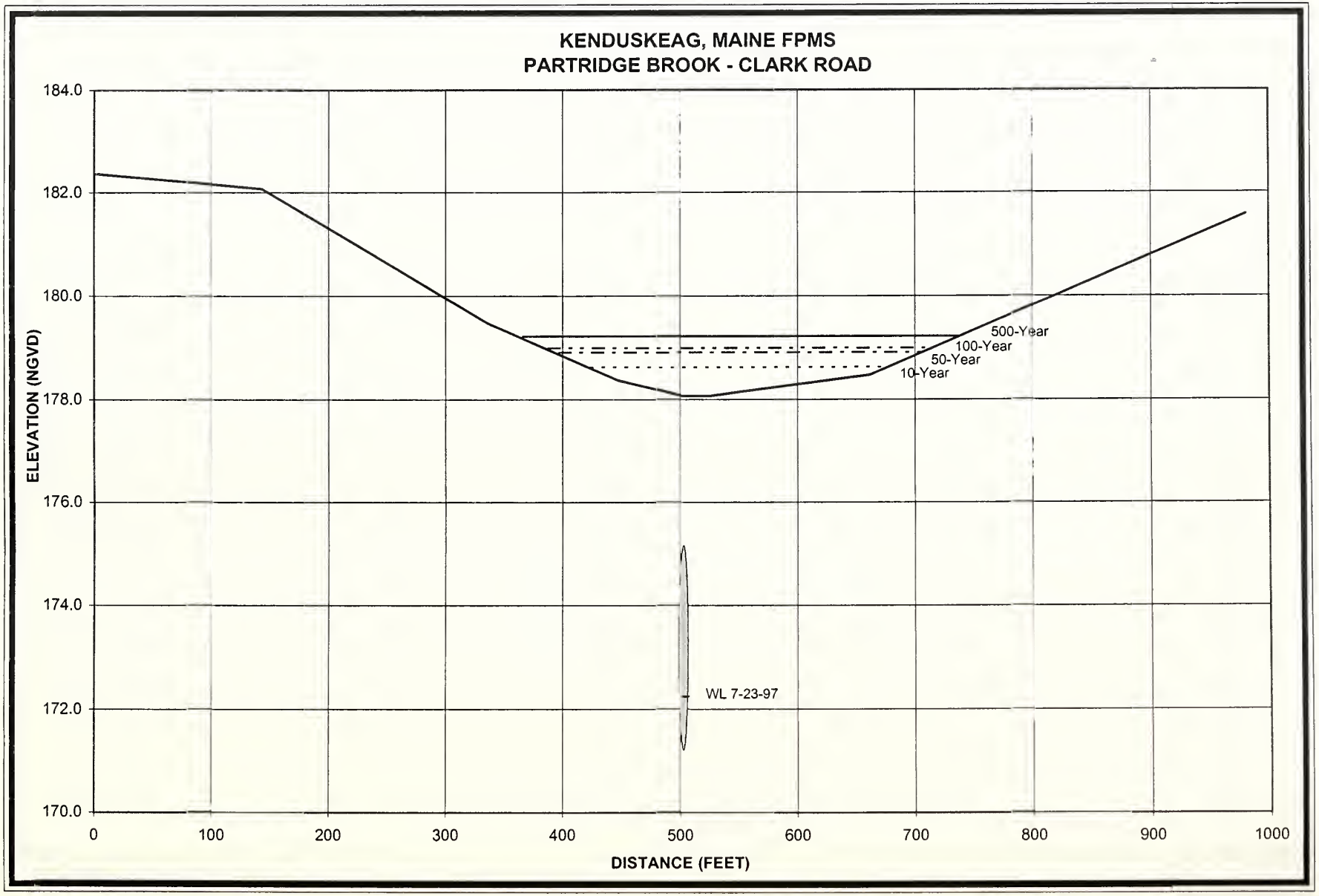
U.S. DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
TOWN OF KENDUSKEAG
FLOODPLAIN MANAGEMENT STUDY
PENOBSCOT COUNTY, MAINE

APPENDIX C
SELECTED CROSS SECTIONS


KENDUSKEAG, MAINE FPMS
KENDUSKEAG STREAM - STETSON ROAD
ELEVATION (NGVD)
135
130
125
120
115
110
105
-600
-500
-400
-300
-200
-100
0
100
200
300
DISTANCE (FEET)
State Route 15
100-Year with ice jam downstream
500-Year
100-Year
50-Year
10-Year
WL 7-8-97


KENDUSKEAG, MAINE FPMS
KENDUSKEAG STREAM - CROSS SECTION I
ELEVATION (NGVD)
145.0
140.0
135.0
130.0
125.0
120.0
0
100
200
300
400
500
600
DISTANCE (FEET)
Robyville Road
500-Year
100-Year
50-Year
10-Year
WL 7-21-97


KENDUSKEAG, MAINE FPMS
PIPER BROOK - MUDGETT ROAD
ELEVATION (NGVD)
204.0
202.0
200.0
198.0
196.0
194.0
192.0
190.0
188.0
186.0
184.0
0
50
100
150
200
250
300
350
DISTANCE (FEET)
Morey Road
100-Year
50-Year
10-Year
Note: The 5 0-year elevation
is too clos to the 100-year
elevation to be shown.
WL 7-8-97


KENDUSKEAG, MAINE FPMS
PARTRIDGE BROOK - CLARK ROAD
184.0
182.0
180.0
178.0
176.0
174.0
172.0
170.0
ELEVATION (NGVD)
0
100
200
300
400
500
600
700
800
900
1000
DISTANCE (FEET)
500-Year
100-Year
50-Year
10-Year
WL 7-23-97